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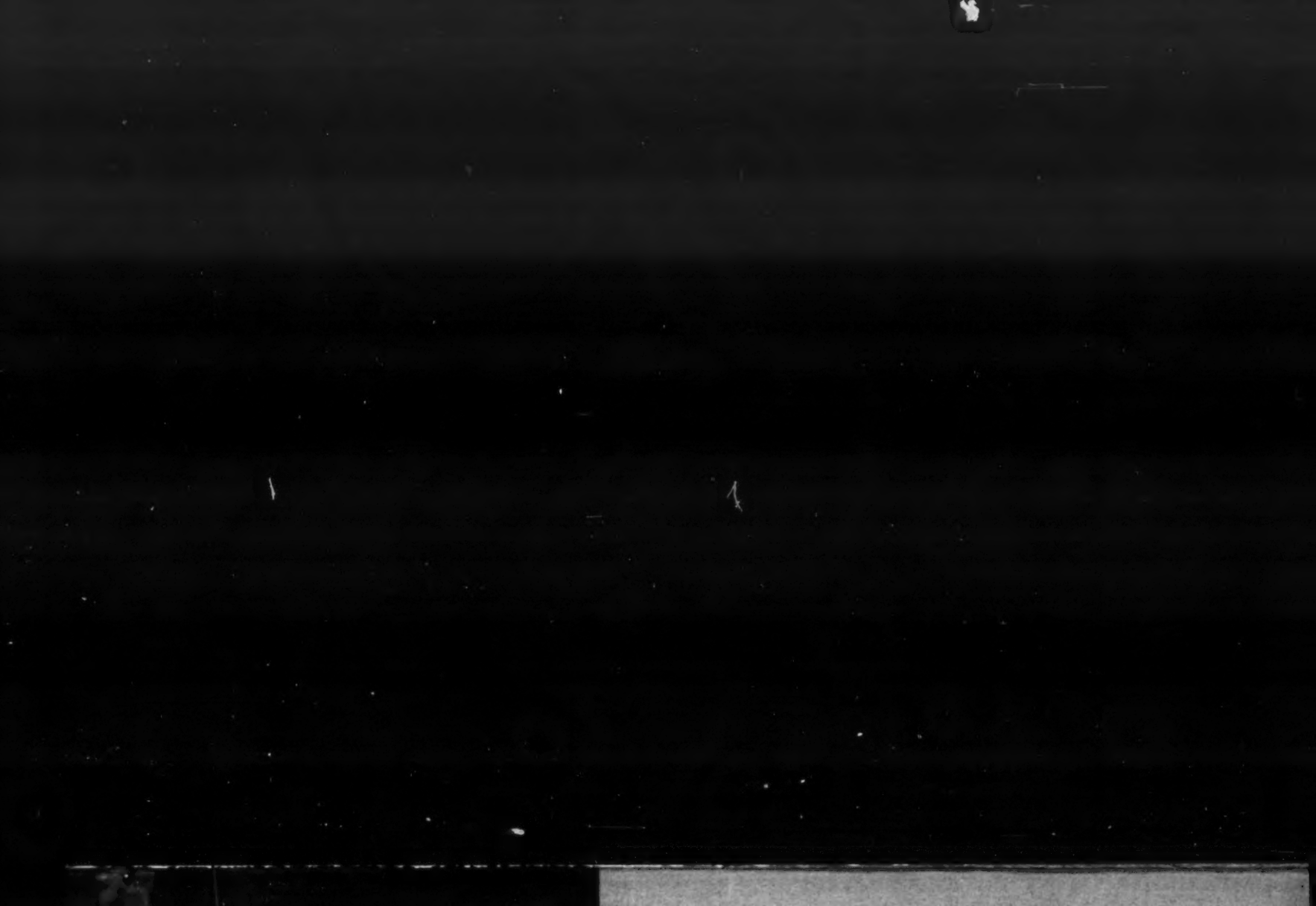

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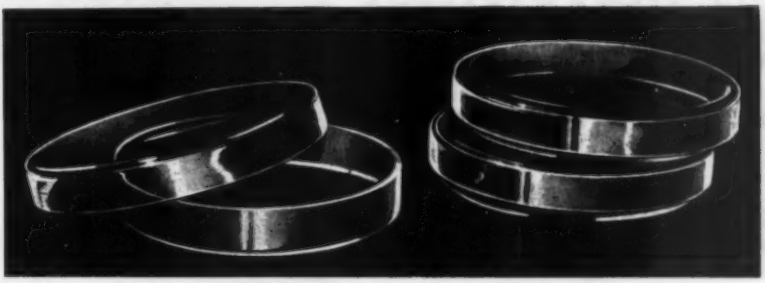

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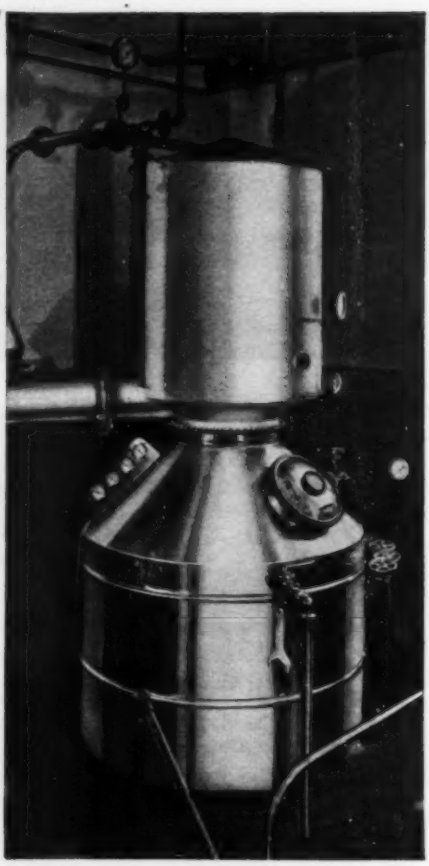

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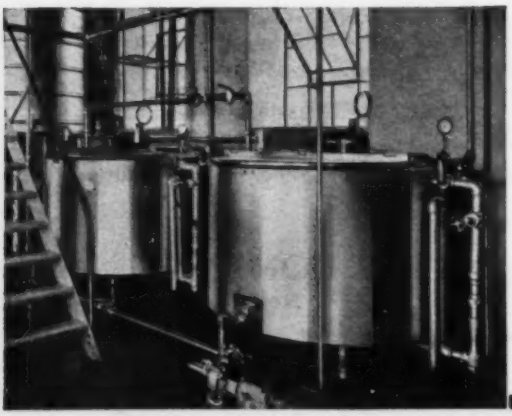

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JOURNAL OF DAIRY SCIENCE

VOLUME XX SEPTEMBER, 1937 NUMBER 9

USE OF ISOPROPYL ETHER IN A MODIFIED MOJONNIER FAT TEST

J. J. JOHNSON

Sealtest, Inc., Research Laboratories, Baltimore, Md.

In recent years many solvents have been made commercially available which heretofore could only be procured in very small quantities at very high prices. While such solvents are now finding their place in the commercial field, apparently very little has been done in analytical laboratories toward adapting analytical methods to the use of these newer reagents. In many instances these products are cheaper and more satisfactory than the old solvents.

Of the low boiling solvents, ethyl ether is probably the one most widely used in chemical laboratories. Petroleum ether, or ligroin, has filled an important place in the laboratory as a fat solvent and reagent and in the analysis and purification of organic compounds. Both of these solvents however are highly volatile and because of their low boiling points and inflammability dangerous when stored under ordinary conditions of temperature.

In the analysis of dairy products both ethyl ether and petroleum ether are used in the Mojonnier method of fat extraction, which has become standard in most dairy laboratories. This method as described by Mojonnier and Troy is accurate but the problem of keeping the ether solvents is a real one. Their low boiling point (98° F.) requires that they be kept in hermetically sealed cans or in cold storage and even then the loss by evaporation is considerable. Also it will evaporate from Mojonnier measuring containers and considerable residue is accumulated from the rubber connections. One way to overcome these difficulties was to substitute for the ether a suitable solvent of relatively high boiling point. Of several solvents which were available isopropyl ether gave the most satisfactory results for use in the Mojonnier test.

Isopropyl ether is a colorless liquid of ethereal odor with a boiling point of 67.5° C.* The commercial product is soluble in water to the extent of

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* *CAUTION:* In dry distilling any ether the possibility of an explosion at the end of the evaporation, due to the presence of peroxides, must be taken into account. Such ether will liberate iodine from an acid solution of potassium iodide and it is advisable to always make this test for peroxides. If found they should be destroyed by washing with a 10 per cent solution of sodium sulphite.

0.65% by volume at 25° C. while water is soluble in it to the extent of 0.025% at the same temperature. It is an excellent solvent for animal, vegetable, and mineral oils, also fats, waxes, and resins. Isopropyl ether is somewhat similar to ethyl ether in properties but does tend to form peroxides more readily than ethyl ether. Consequently the presence or absence of peroxides should be determined by the method mentioned in the footnote and if present, should be destroyed with sodium sulphite before distillation. Its boiling point is higher than that of ethyl ether and its vapor pressure lower, a decided advantage in extraction process. Furthermore, the low solubility of water in isopropyl ether is a distinct advantage in the determination of fats by the Mojonnier method. In the Mojonnier method of analysis isopropyl ether has a tendency to form an emulsion with water solutions but a perfect separation without the aid of a centrifuge is easily procured by the addition of alcohol to the water solution.

In the experimental trials fat determinations were made on milk, buttermilk, cream, sour cream, dry milk, evaporated milk and ice cream using isopropyl ether and the results compared with those obtained by the standard Mojonnier method using ethyl and petroleum ether. A slight modification was necessary in the amount of alcohol and water used with the isopropyl ether in the analysis of the different products. The results were excellent and in the analysis of certain products more accurate than when ether and ligroin were used due to the carrying over of milk solids by the ethyl and petroleum ether mixture.

PROCEDURE

Approximately 5 grams of the milk product are weighed directly in the Mojonnier flask, or if the sample is sufficiently fluid the Mojonnier weighing pipettes may be used. Seven cc. of distilled water are added (10 cc. of water when testing dry milk) and the solution well mixed. One and a half cc. of concentrated ammonia is then added and mixed with the weighed sample. To this is added 12 cc. of alcohol and the solution again mixed. Twenty-five cc. of isopropyl ether are now added and the flask shaken for 20 seconds after which it is allowed to stand for 15 minutes or centrifuged as in the standard method.

The separated ether layer is poured off into the weighed aluminum dish and a second extraction made as follows: Five cc. of alcohol are added and mixed with the solution, then 25 cc. of isopropyl ether and the flask shaken for 20 seconds, after which it is allowed to stand for 20 minutes or centrifuged.

The ether layer is raised to the mark if necessary by the addition of 50% alcohol and the ether poured into the aluminum dish containing the first extraction. The ether is evaporated off on a hot plate at a low heat using an asbestos pad.

The dish is then placed in the drying oven for 30 minutes at 100° C., cooled in the atmosphere and weighed.

TABLE I

Comparison of butterfat determinations between the Standard Mojonnier Method and Modified Method using isopropyl ether

SAMPLE NO.	PRODUCT	TEST NO.	STANDARD MOJONNIER METHOD	MODIFIED MOJONNIER METHOD
			Per cent fat	*Per cent fat*
1	Ice Cream	1	14.38	14.41
	" "	2	14.39	14.42
	" "	3	14.41	14.47
			Average 14.39	14.43
2	" "	1	13.96	13.90
	" "	2	13.94	13.99
	" "	3	13.93	13.89
	" "	4	13.92	13.95
	" "	5	13.90	13.98
	" "	6	13.94	13.90
	" "	7	.....	13.91
	" "	8	.....	13.97
	" "	9	.....	13.96
	" "	10	.....	13.98
	" "	11	.....	13.99
			Average 13.93	13.95
1	Sour Cream	1	18.96**	18.95
	" "	2	18.98**	18.93
	" "	3		19.07
	" "	4		18.98
			Average 18.97	18.98
2	" "	1	19.04	19.05
	" "	2	19.07	19.08
	" "	3		19.08
	" "	4		19.01
			Average 19.06	19.06
1	Milk	1	3.94	4.01
	"	2	3.99	3.95
	"	3	3.95	4.00
			Average 3.96	3.99
1	Buttermilk	1	0.51	0.52
	"	2	0.54	0.53
	"	3	0.54	0.53
			Average 0.53	0.53
1	Evaporated Milk	1	7.61**	7.65
	" "	2	7.64**	7.57
	" "	3	7.66**	7.62
	" "	4	.....	7.62
1	Milk Powder	1	4.32	4.30
	" "	2	4.29	4.31
	" "	3	4.30	4.33
	" "	4	4.29	4.29
			Average 4.30	4.31
2	" "	1	0.85**	0.85
	" "	2	0.81**	0.85
	" "	3	0.83**	0.87
	" "	4	.....	0.89
	" "	5	.....	0.87
	" "	6	.....	0.86
			Average 0.83	0.87

** These results corrected for solids not fat observed to be present in the extracted fat. The average correction was – 0.20% as determined by actual weight.

In the Mojonnier standard method of analysis it is not unusual to observe a small percentage of solids not fat in the fat extract, which is corrected for by washing out the fat and weighing the solids. This is due to the solubility of the water alcohol solution in the ether. When isopropyl ether is used, the fat extract is in every case free from solids not fat.

TABLE I—(*Continued*)
Comparison of butterfat determinations between the standard Mojonnier method and modified method using isopropyl ether

SAMPLE NO.	PRODUCT	TEST NO.	STANDARD MOJONNIER METHOD		MODIFIED MOJONNIER METHOD	
			Per cent fat		*Per cent fat*	
3	Milk Powder	1	0.91		0.92	
	" "	2	0.85		0.97	
			Average	0.88		0.95
2	" "	1	0.85		0.88	
	" "	2	0.88		0.89	
			Average	0.87		0.89
5	" "	1	1.06		1.06	
	" "	2	1.11		1.11	
			Average	1.09		1.09

The usual Mojonnier procedure of evaporating the ether, drying and cooling may be followed if the Mojonnier apparatus is at hand.

DISCUSSION

Isopropyl ether offers no storage problem in hot weather and may be kept in the Mojonnier measuring apparatus without loss by evaporation such as experienced when using ethyl and petroleum ether. The low solubility of water in isopropyl ether is a distinct advantage in the determination of fat by the Mojonnier method. The use of a centrifuge is not required in order to assure complete separation of the isopropyl ether from the water alcohol solution of milk solids and the time required for an analysis is less in that the number of operations is reduced.

Technical isopropyl ether may be purchased practically free from non-volatile residue, making redistillation or blank determinations unnecessary. It is shipped in 1, 5, and 55 gallon non-returnable steel containers at an approximate cost of sixty cents per gallon and the deposit of four to eight dollars required on ethyl and petroleum ether containers is eliminated.

Isopropyl ether has a greater tendency to form peroxides than ethyl ether when kept in storage over long periods of time. Therefore there is more danger when making a dry distillation if the peroxides are not first destroyed. Storage over water or reducing agents inhibits the formation of peroxide.

The tendency of isopropyl ether to form an emulsion with water solutions requires the proper dilution of the solution with alcohol as shown in the procedure in order to get a clean cut separation.

SUMMARY

Results obtained in the extraction of fat from dairy products by this modified Mojonnier method are more accurate when using isopropyl ether than those with ethyl and petroleum ether, when no correction is made for milk solids carried over by the ethyl ether.

The use of isopropyl ether for fat extractions instead of ethyl and petroleum ether is time-saving, more convenient, and cheaper.

IMPROVED NOMOGRAPHIC CHARTS FOR DETERMINING THE RELATIVE VALUE OF FEEDS

G. W. SALISBURY, J. I. MILLER AND A. Z. HODSON
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One of the most important problems confronting the livestock feeder is the purchasing of feeds economically. Whatever the circumstance, whether he is buying concentrates or roughages, to purchase the most feeding value per dollar is the object of the average man when buying feeds. Various criteria have been set up to aid the livestock feeder in purchasing feeds economically. It is generally recognized that the price of a feed is not a reliable indication of its value. Consequently, other methods based upon the nutrients contained in the feed which may actually be digested and utilized by the animal are much more reliable and worthwhile. It must be borne in mind that no system of measuring the nutritive value of feeding stuffs yet devised adequately considers the matter of quality of protein, minerals, vitamins, physical make-up or palatability. Such factors must be taken into consideration when feeds are purchased for feeding to livestock.

Perhaps the most widely used of these methods is that based upon the cost of one hundred pounds of total digestible nutrients. By use of this method it is possible to compare the value of one concentrate with another on the basis of the economy with which it supplies a unit of total digestible nutrients or carbohydrate equivalent. However, this method can be applied accurately, for feeds which are to be fed to animals for productive purposes, only when feeds are compared which have approximately the same fiber content. This is because of the fact that the energy cost of digestion is greater for feeds of a high fiber content. Consequently one hundred pounds of total digestible nutrients in a roughage is not equal in value for productive purposes to a similar amount of total digestible nutrients in a concentrate. This is also true in the case of concentrates widely different in fiber content.

In addition, as protein serves a special function in the body, this method is in error as it fails to consider the amount of protein contained in a feed. Therefore, a high-protein feed does not receive its proper ranking when it is to be used as a supplement to balance a ration low in protein, unless this feed is a cheap source of total digestible nutrients. Under usual price relationship high-protein feeds are higher in price than low-protein feeds, such as the cereal grains. Ordinarily, then the high-protein feeds would not be an especially cheap source of total digestible nutrients.

In order to properly evalute a feed, the fact that protein is especially important as a nutrient, and the fact that each unit of protein is actually

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worth more than a unit of starch when high-protein feeds are higher in price than the low-protein feeds, must be taken into consideration. An attempt has been made to accomplish this by charging the entire cost of a high-protein feed to the protein and then determining the cost of a unit of protein. This method is obviously as much in error as the other, as it disregards the value of the remainder of the total digestible nutrients. A combination of the two methods, by which the value of a feed could be determined no matter what its composition and what price relationships exist between high-protein and low-protein feeds, would be ideal.

It is apparent that such a system to be accurate must then be based upon accurate net energy values and digestible protein, rather than upon total digestible nutrients and digestible protein. By the use of accurate net energy values it would then be possible to compare concentrates with roughages, and concentrates of low-fiber content with those higher in fiber. Unfortunately this is almost a practical impossibility, as few reliable data exist regarding the net energy values of our common feeding stuffs.

Consequently, a compromise has been necessary and a system of evaluating feeds based on their content of digestible protein and digestible nutrients has been developed. According to Petersen, Hayden of the Ohio Agricultural Experiment Station was the first to develop a method of evaluating a feed in which digestible protein was considered, as well as its content of total digestible nutrients. This method was designated as the cost per pound of "excess protein."

Petersen (2) devised a method using cottonseed meal as one base feed, representing an ordinarily cheap source of digestible protein, and corn, representing a cheap source of total digestible nutrients, as the other base. Petersen described his method in detail in 1932 and included a table showing constants for certain common feeds by which the price of the high-protein base feed and the price of the low-protein base feed must be multiplied and the result added, to obtain the value of the particular feed in question. A nomograph was presented on which, by aid of a straight edge, the value of a feed could be obtained with cottonseed meal and corn at any price. This obviated the need of computations. Stothart (3) adapted the Petersen method to Canadian conditions by calculating a series of constants for the common Canadian feeds based on linseed meal and barley as base feeds. He, also, prepared a nomographic chart which could be used to eliminate the calculations.

This method of evaluating feeding stuffs has found wide acceptance and is extremely useful. However, it is wholly accurate only when high-protein feeds are higher in price than low-protein feeds per unit of total digestible nutrients. When no premium is placed on protein, or when a pound of protein costs less than a pound of starch this method is inaccurate as it penalizes a feed for its protein content. When such a market condition

exists feeds should be compared only on the basis of the economy with which they supply total digestible nutrients.

With these facts in mind, the authors have developed the nomographic charts illustrated in this paper. These are based upon the Petersen method but are more comprehensive in that it is possibe to compare the value of feeds by three different methods all on the same chart. First, the relative value of feeds may be read from the chart according to the Peterson method. This method should be used only when high-protein feeds are higher in price than low-protein feeds. When there is no premium in price placed upon a unit of protein either of the remaining methods should be used. Second, the relative value of feeds based solely on their content of total digestible nutrients, or in some cases net energy, may be read from the chart. Third, for those who prefer to compare feeds on the basis of their relative cost per 100 pounds of total digestible nutrients, or cost per 100 therms of net energy, these values may be read from the chart with the feed at any particular price.

These charts are based upon the constants and factors for valuing feeding stuffs in Appendix Table VIII of Feeds and Feeding (1) which in turn are based upon the tables of composition and net energy values found in the same text. The constants and factors for all of the roughages and for a few concentrate feeds high in fiber are based upon the estimated net energy values of these feeds, the remainder are based upon the amount of total digestible nutrients which these feeds contain. For the original computations cottonseed meal containing 43 per cent protein was used as one base feed, while No. 2 corn was used as the other. This, however, does not affect the usefulness of the alignment charts as any economical source of protein may serve as one base feed and any cheap source of total digestible nutrients may be used as the other, when comparing feeds by the Petersen method.

It is fully recognized that such a chart does not consider many items of monetary value such as quality of protein, minerals, vitamins, physical make-up of the feed, or palatability, which unquestionably should be given careful consideration when purchasing feeds. It is also appreciated that the value of certain feeds for one class of stock may radically differ when fed to another class of stock. These charts have been developed as an aid to the feeder when purchasing feeds, but certainly cannot be used as a substitute for knowledge of the importance of the above factors.

DIRECTIONS FOR USING CHARTS

Charts 1 and 2 are based entirely upon the amounts of total digestible nutrients and digestible protein contained in each of the feeds. Most of the common concentrate feeds are to be found on these two charts. On the other hand, Charts 3 and 4 contain the common roughages fed to livestock and, as well, a few common concentrate feeds in order that a comparison

may be made of the relative value of the two types of feeds. These charts are based upon the estimated net energy values of these feeds and the amounts of digestible protein they contain.

The methds of determining the relative values of feeds are relatively simple and nc equipment is required other than the charts and a straight edge. A ruler or black thread will be found to be very satisfactory.

Evaluating Feeds When Protein-rich Feeds Are Higher in Price Than Farm-Grown Grains

Place the chart so that the names of the feeds are at the left. The figures on each line representing a feed are the prices per ton of that feed. This line is calibrated in units of $1.00. Now select one feed as the low-protein base feed. This should be one of the farm-grown cereal grains or hominy feed, the one selected being the feed which seems cheapest. As the other base feed, the high-protein feed should be used which is apparently the cheapest source of protein.

When you have selected the base feeds, place a ruler or other straight edge with the edge toward the left, or a black thread will work nicely, on the price per ton of the low-protein base feed. Now, keeping the straight-edge on the particular price of the low-protein feed, place the edge of it on the line representing the high-protein base feed at its price per ton. The values of all other feeds may then be read off where the straight-edge crosses the line for each feed. For example; using Chart 1 and taking corn No. 2 at $30.00 and cottonseed meal at $40.00 a ton as the base feeds, rye is worth $31.00; wheat bran $29.00 plus; distillers' corn grains, dried, $38.00; brewers' grains, dried, $31.00; and corn gluten meal $43.00, per ton.

If the actual price of any one of these feeds is less than the value indicated, it is a good buy in terms of the base feeds. Naturally, the feeds which supply nutrients the most economically and from which the most satisfactory ration can be compounded should be purchased.

Under usual circumstances this method should be used in the selection of economical feeds. However, occasionally, as has been the case several times during the past two or three years in New York, certain high-protein feeds sell at a price which places no premium on the protein they contain. When this is the case the concentrates should be compared on the basis of the economy with which they furnish total digestible nutrients or net energy.

This price relationship between high-protein feeds and low-protein feeds may be readily determined from the chart. When the straight-edge is parallel to the base at the left as indicated by the guide lines at the top and bottom of the nomograph the basis of comparison is on total digestible nutrients or net energy alone. Under no circumstances should feeds be compared on these charts when the straight-edge is placed on the chart in

such a manner that the number of divisional markings on the top guide lines is less than the number on the bottom guide lines.

Evaluating Feeds When Protein-Rich Feeds Are as Cheap as the Grains

To compare feeds on the amount of total digestible nutrients or net energy which they contain, with no consideration given to the relative content of digestible protein, the straight-edge must be held in the same position as above, but must be parallel to the left side of the chart. This may be done by means of the guide lines which are placed at the top and bottom of chart. The straight-edge is parallel to the left side of the chart when it rests on the same divisional marking on the top and bottom guide lines.

Select any feed which appears to be economical as a base feed and move the ruler to the left until it rests at the price per ton of that feed. Be sure that the straight-edge is parallel to the left side of the chart. The relative value of the other feeds on the basis of total digestible nutrients or net energy and in relation to the base feed may then be determined by reading off the figures for each feed where the straight-edge crosses the line representing that feed. For example, using Chart 1, with corn at $30.00 a ton as the base feed, the straight-edge is parallel with the left of the chart when it rests at the 18¾ mark on the guide lines. In this example, wheat would be worth $31.00; wheat bran $26.00; soybeans $32.00; and cottonseed meal about $28.00 a ton.

When the actual price of a feed appears to the left of the straight-edge the feed is an economical one in relation to the base feed. If it appears to the right it is too expensive on the basis of the total digestible nutrients or net energy it contains and should not be purchased unless it has other virtues.

Calculating the Cost per 100 Pounds Total Digestible Nutrients or the Cost per 100 Therms Net Energy

Owing to the prevalence of the practice some who use the chart may wish to calculate the cost of 100 pounds of total digestible nutrients, or the cost of 100 therms of net energy. This may be done very easily, if the straight-edge is parallel to the left of the chart, by placing the left edge of the straight-edge on the price of any feed for which it is desired to know the cost per 100 pounds total digestible nutrients or 100 therms net energy, and then reading off the cost on the line which is labelled "cost per 100 pounds total digestible nutrients" on Charts 1 and 2, or "cost per 100 therms net energy" on Charts 3 and 4. This line is calibrated in units representing $0.10, while by estimation it seems possible to read the cost to the nearest $0.05. On Chart 1 when corn costs $30.00 a ton it furnishes 100 pounds of total digestible nutrients for about $1.85.

If one wishes to compare the value of a feed on one chart with that of a feed on another, it is possible to do so by noting the calibration on the cottonseed meal line (43% protein) and on the corn line where the straight-edge crosses them and then placing the straight-edge on the same marks on the cottonseed meal and corn lines on the other chart. In transferring from a chart based on total digestible nutrients to another calculated on the same basis, the comparison is, of course, identical. However, there will be some variation in changing from a chart based on total digestible nutrients to one based on net energy. This is true of oats, barley, and distillers' corn grains, dried, as they are found on both Charts 1 and 3 and in one case the basis of comparison is total digestible nutrients and the other is net energy.

These charts, in a size from which the information may be more easily read may be obtained from the authors.

SUMMARY

Four nomographic charts are presented from which the relative value of feeds may be determined for the common feeds by three different methods.

1. The Petersen method. To be used only when high-protein feeds are higher in price than low-protein feeds.

2. The method of comparing feeds on the basis of their relative content of total digestible nutrients or net energy. To be used when protein-rich feeds are as cheap as the grains.

3. The cost per 100 pounds of total digestible nutrients or 100 therms of net energy. To be used as under method 2 above.

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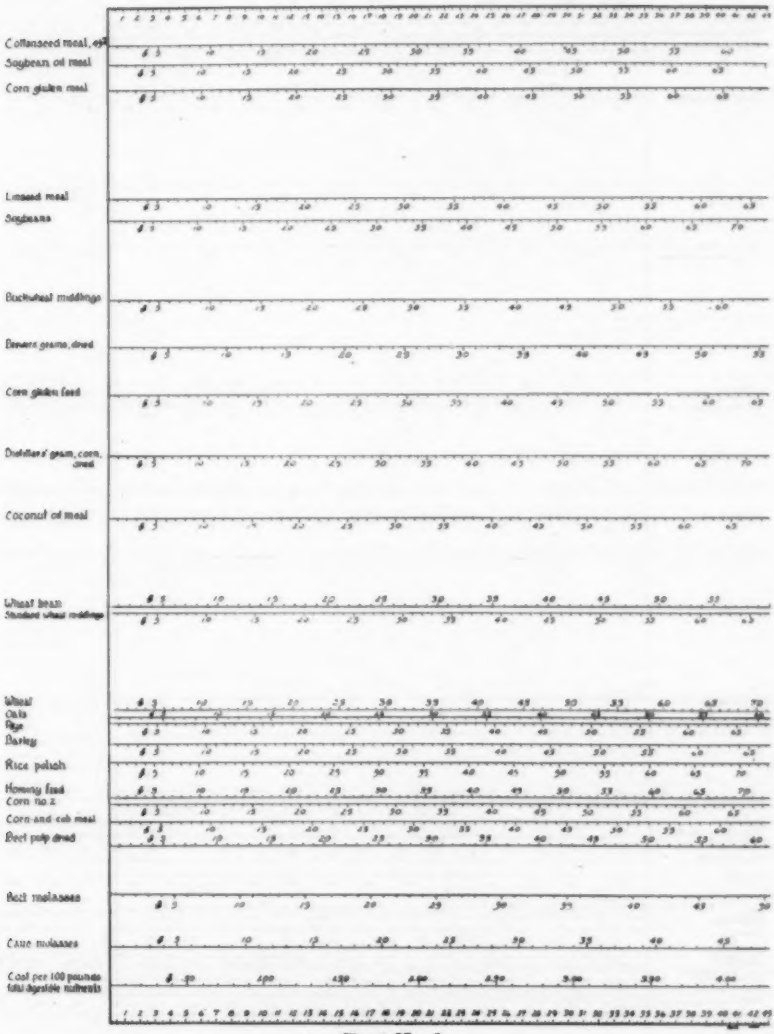
Cottonseed meal, 43%
Soybean oil meal
Corn gluten meal
Linseed meal
Soybeans
Buckwheat middlings
Brewers grains, dried
Corn gluten feed
Distillers' grain, corn, dried
Coconut oil meal
Wheat bran
Standard wheat middlings
Wheat
Oats
Rye
Barley
Rice polish
Hominy feed
Corn no 2
Corn-and-cob meal
Beet pulp dried
Beet molasses
Cane molasses
Cost per 100 pounds total digestible nutrients

Chart No. 1

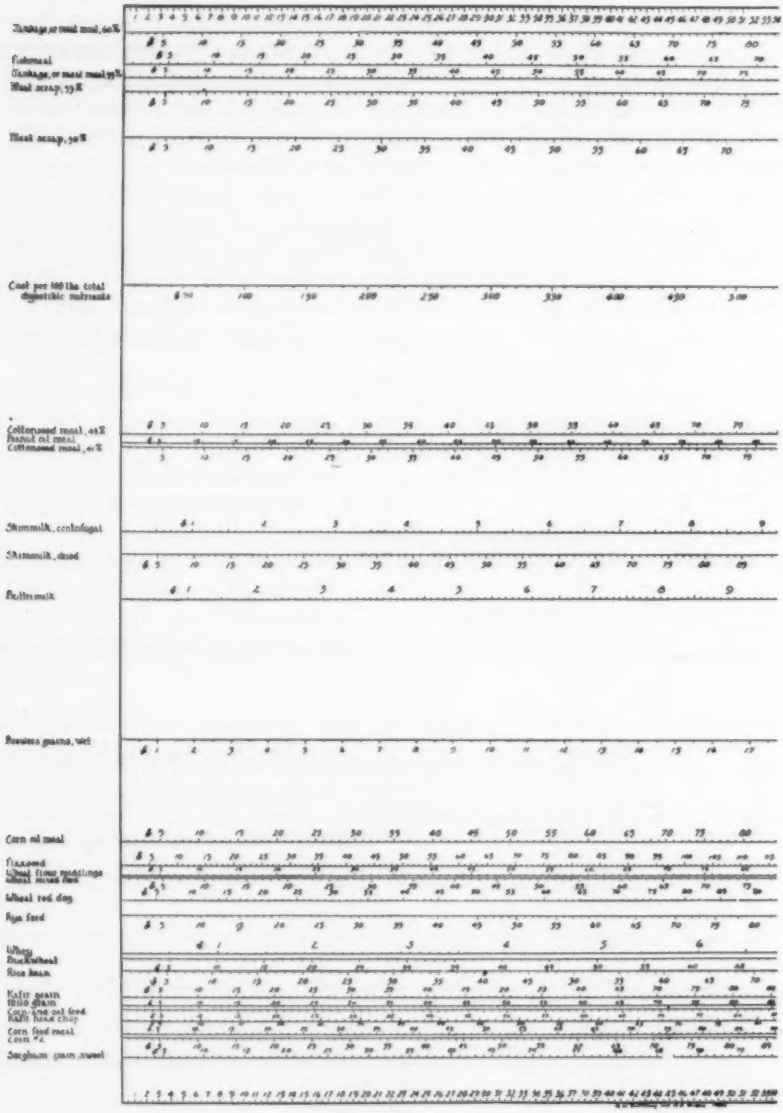
Cost per 100 lbs total digestible nutrients
Skimmilk, centrifugal
Skimmilk, dried
Buttermilk
Brewers grains, wet
Corn oil meal
Flaxseed
Wheat flour middlings
Wheat mixed feed
Wheat red dog
Rye feed
Whey
Buckwheat
Rice bran
Kafir grain
Milo grain
Corn-and-cob feed
Kafir head chop
Corn feed meal
Corn "Z"
Sorghum grain, sweet

Chart No. 2

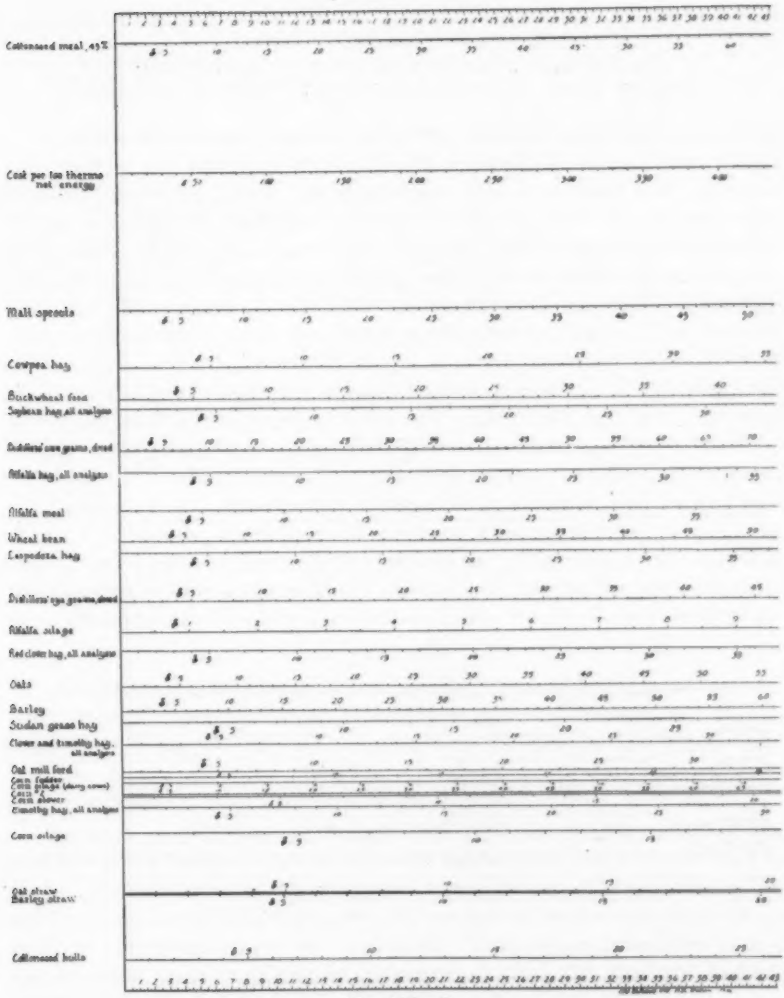
Cottonseed meal, 43%
Cost per ton therms net energy
Malt sprouts
Cowpea hay
Buckwheat feed
Soybean hay, all analyses
Distillers' wet grains, dried
Alfalfa hay, all analyses
Alfalfa meal
Wheat bran
Lespedeza hay
Distillers' rye grains, dried
Alfalfa silage
Red clover hay, all analyses
Oats
Barley
Sudan grass hay
Clover and timothy hay, all analyses
Oat mill feed
Corn fodder
Corn silage (dent corn)
Corn ?
Corn stover
Timothy hay, all analyses
Corn silage
Oat straw
Barley straw
Cottonseed hulls

Chart No. 3

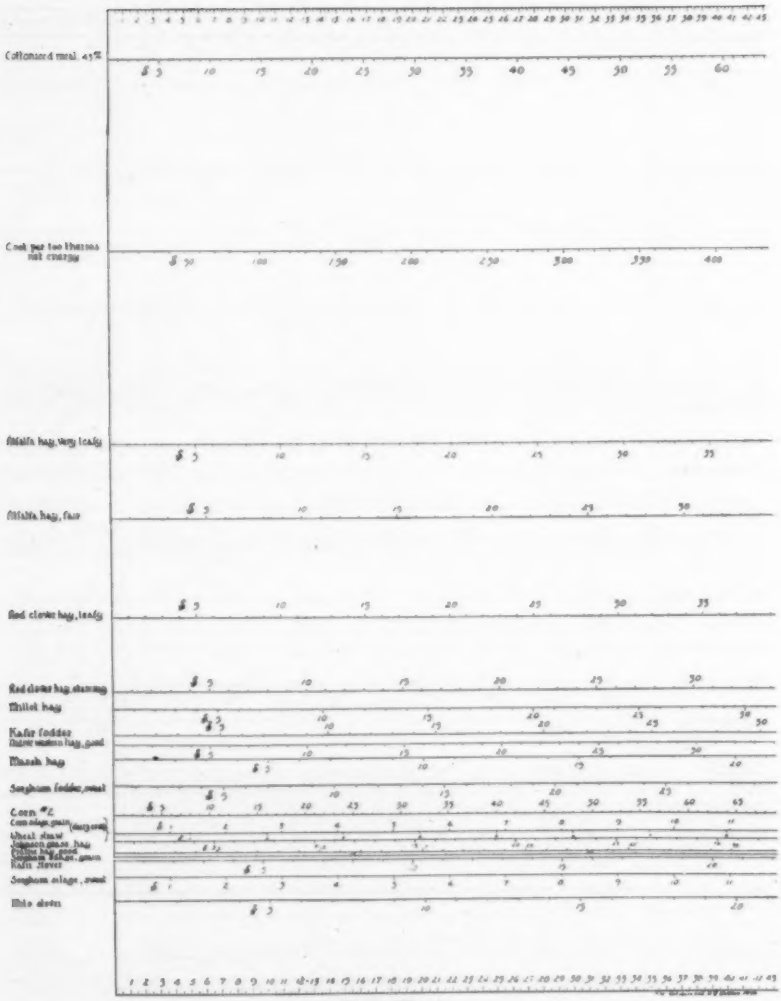
Cottonseed meal 41%
Cost per ton therms net energy
Alfalfa hay, very leafy
Alfalfa hay, fair
Red clover hay, leafy
Red clover hay, stemmy
Millet hay
Kafir fodder
Timothy hay, good
Wheat straw
Johnson grass hay
Cotton hay, good
Sorghum fodder, good
Corn silage, good
Corn silage, poor
Kafir stover
Sorghum silage, good
White straw

Chart No. 4

FURTHER STUDIES ON SKIMMILK AGAR FOR ROUTINE MILK COUNTS

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Previous studies on modifications of the standard agar plating medium approved by the American Public Health Association revealed that a combination containing 2.0 per cent fluid skimmilk, 0.5 per cent Bacto peptone, 0.1 per cent each of Bacto beef extract and glucose and 1.5 per cent agar, gave counts on 618 pasteurized milk samples which were from two to four times as large as corresponding counts using the approved standard agar (1). On 137 samples of raw milk, the counts with the modified medium were only slightly greater than those on the standard agar. The presence of skimmilk increases the size of the colonies and permits differentiation of acid-producing and caseolytic types. Excessive amounts of skimmilk may be precipitated in the medium while less than 2 per cent will not allow definite differentiation of colony types (2).

Tryptone, a trypsin hydrolyzed casein, is superior to peptone as a source of nitrogen (3, 4). Bowers and Hucker in their media comparisons have shown that an agar containing 0.5 per cent tryptone, 0.1 per cent glucose, and 1.5 per cent agar, gave the highest counts. They also found that bacterial counts on this agar might be increased slightly by the addition of 0.5 per cent skimmilk.

NEW DATA

The data herein summarized were secured from a comparison of bacterial counts on milk samples using (1) standard agar, (2) Bowers and Hucker basic medium plus 0.5 per cent skimmilk and (3) Bowers and Hucker basic medium plus 2.0 per cent skimmilk. The samples represent essentially 215 widely distributed New York State milk supplies.

Based on the average percentage differences, the counts on pasteurized milk with the tryptone-glucose-skimmilk agars were about three times as large as the corresponding standard agar counts. The counts on the medium containing the 2.0 per cent skimmilk were larger than those on the medium containing 0.5 per cent skimmilk. With raw milk samples each of the skimmilk agars gave slightly higher counts than the standard medium. The results on only 209 of the 215 samples are compared in Table 1.

The distribution of percentage differences in counts on pasteurized milk with each of the two skimmilk agars as compared with the standard agar count is shown in Table II. Nearly all of the counts on the two skimmilk agars were higher than the standard agar count, only a few being definitely less than the standard count.

TABLE I

Average percentage increase of counts on tryptone-glucose-skimmilk agars over standard agar count

SAMPLES	NO. TESTED	SKIMMILK CONTENT OF AGAR	
		0.5 PER CENT	2.0 PER CENT
Pasteurized milk	190	180 per cent	215 per cent
Raw milk	19	17 per cent	16 per cent

TABLE II

Frequency of percentage differences between counts on tryptone-glucose-skimmilk agars and standard agar count—pasteurized milk samples

PERCENTAGE DIFFERENCE RANGE	NUMBER OF SAMPLES	
	0.5% SKIMMILK	2.0% SKIMMILK
Negative values greater than 25 per cent	3	5
−1 to −25 per cent	17	12
0 to 25 per cent	40	28
26 to 100 per cent	74	79
101 to 200 per cent	26	31
201 to 500 per cent	17	19
501 to 2000 per cent	11	14
Over 2000 per cent	2	2
Total	190	190

Since a more direct comparison of the two skimmilk media was desired, the percentage differences between the counts obtained on pasteurized milk with these media were determined. The distribution of these differences given in Table III shows that the 2 per cent skimmilk agar gave higher counts on 117 samples (positive percentage difference), lower counts on 67 samples and the same count on 12 samples. From the standpoint of maximum counts, the 2 per cent skimmilk agar is preferred.

TABLE III

Frequency of percentage differences between counts on 2 per cent skimmilk agar and 0.5 per cent skimmilk agar—pasteurized milk samples

PERCENTAGE DIFFERENCE RANGE	NUMBER OF SAMPLES
Negative values greater than 50 per cent	5
−26 to −50 per cent	6
−11 to −25 per cent	22
−1 to −10 per cent	34
0 to 10 per cent	51
11 to 25 per cent	42
26 to 50 per cent	23
51 to 75 per cent	9
Over 75 per cent	4
Total	196

A graphic illustration of these results is shown in Figures I, II, and III. In Figures I and II, the logarithms of the standard agar counts are charted on the diagonal line, while the logarithms of the corresponding skimmilk agar counts appear at terminals or on the vertical lines above or below the point where the standard agar count is plotted. Figure I compares the magnitude of the standard agar counts and the tryptone-glucose-0.5 per cent skimmilk agar counts. The comparison is identical in Figure II except that 2.0 skimmilk replaces the 0.5 per cent skimmilk. Since practically all of the

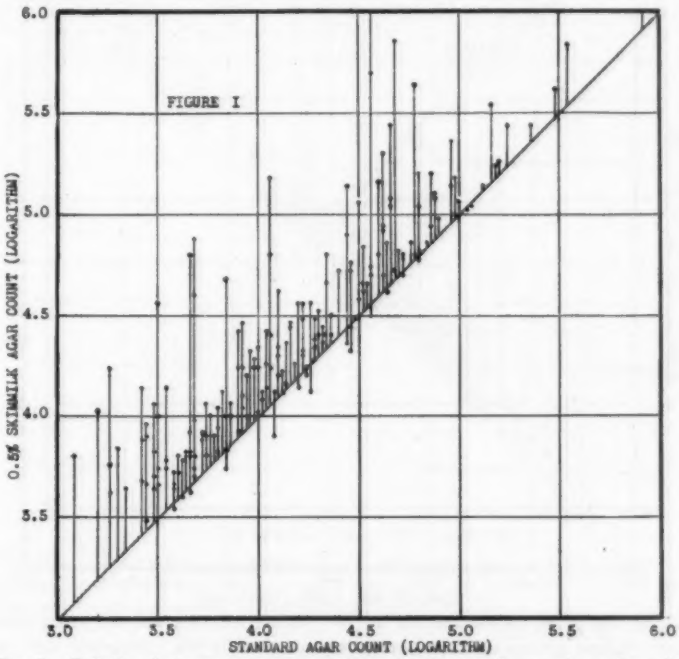

FIG. 1. Relation between counts on 190 pasteurized milk samples using standard agar and tryptone glucose agar containing 0.5 per cent skimmilk. Standard agar counts plotted on diagonal line.

vertical lines of appreciable length are above the diagonal, it is obvious that nearly all of the skimmilk agar counts are greater than the standard agar counts.

Figure III is a similar comparison but limited to the two skimmilk agars, the 0.5 per cent skimmilk agar counts being plotted on the diagonal. While the logarithmic differences are not great, they do distinctly show a trend in favor of the medium containing the 2.0 per cent skimmilk.

The logarithmic averages of the standard agar plate counts, the 0.5 per

cent skimmilk agar counts, and the 2.0 per cent skimmilk agar counts are respectively 15,100, 27,700 and 29,200. On this basis, the 0.5 per cent skimmilk agar counts averaged 83 per cent greater than the standard agar counts. The 2.0 per cent skimmilk agar counts averaged 93 per cent more than the standard agar counts and 5.4 per cent more than the 0.5 per cent skimmilk agar counts; thereby confirming previous statements in this report.

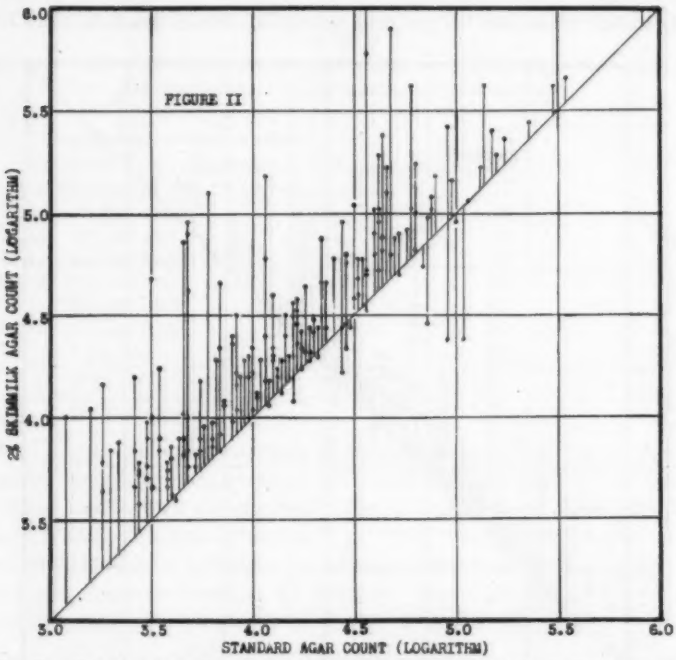

FIG. II. Relation between counts on 190 pasteurized milk samples using standard agar and tryptone glucose agar containing 2 per cent skimmilk. Standard agar counts plotted on diagonal line.

SUMMARY AND CONCLUSIONS

Tryptone-glucose-skimmilk agar media containing (a) 0.5 per cent skimmilk and (b) 2.0 per cent skimmilk, gave counts on 190 samples of pasteurized milk which averaged significantly higher than those obtained on standard agar. Using arithmetical averages of percentage differences, the 0.5 per cent skimmilk agar counts were 180 per cent higher and the 2.0 per cent skimmilk agar counts 215 per cent higher than the corresponding standard agar counts.

The 2.0 per cent skimmilk agar possesses differential value for bacterial

types which obviously can be disregarded when only the total count is desired. The advantages gained in using one medium which has differential value would also be noted in the bacteriological examination of various types of dairy products, such as butter, cheese and starters.

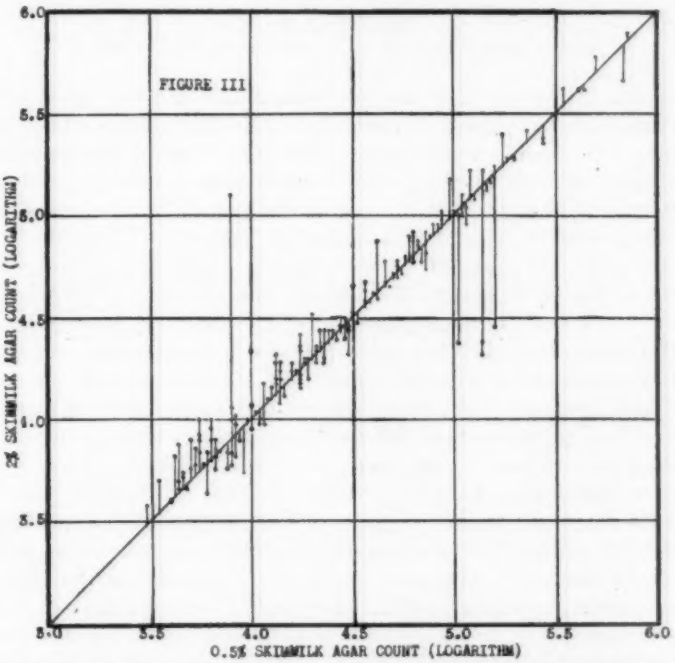

FIG. III. Relation between counts on 190 pasteurized milk samples using tryptone glucose agar containing 0.5 per cent skimmilk and 2 per cent skimmilk. The 0.5 per cent skimmilk agar counts are plotted on the diagonal line.

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WORKING MAINTENANCE AS A FUNCTION OF LIVE WEIGHT IN DAIRY COWS, AND ITS BEARING ON AN ENERGY–SIZE INDEX OF LACTATION

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The term "working maintenance" is here used to refer to that portion of the total nutritional (digestible nutrient or digestible feed energy) cost of milk production, which as between dairy cows of different live weights is properly chargeable to maintenance under practical working conditions in the milking herd. Working maintenance is a major item in the feed cost of milk production. Its proper expression as a function of live weight is of intense practical interest. Using symbols,[1] Haecker (1) expresses it as $DN'' = .007925W$. Brody and Procter (2) express it as $DN'' = .053W^{.73}$. Haecker derived his formula from determinations of the digestible nutrients required to maintain dry farrow cows, and from skilled observation as to how the values so obtained fitted into practice in the milking herd at the Minnesota Station. Brody and Procter derived their formula: first, by determination of basal metabolism as between species varying in live weight from ½ ounce (mouse) to 4 tons (elephant) and found it could be beautifully expressed as $Q = 39.5W^{.734}$, where Q is basal metabolism in calories per day; second, by assuming that working maintenance is simply a multiple of basal metabolism or directly proportional to $W^{.73}$; third, by statistical treatment of the published experimental data of feed, live weight and milk yield of the milking cows of Haecker and other Experiment Station sources. Their treatment of the data gives no information as to the validity of the exponent .73 in the equation $DN'' = .053W^{.73}$ but merely derives the coefficient .053 if .73 is the proper exponent.

The present paper attempts to compare the validity of Brody and Procter's working maintenance exponent .73 with Haecker's working maintenance exponent 1.00, by obtaining a first approximation to the exponent

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[1] Symbols are used, to apply to each experimental period for each cow as follows:

DN = digestible nutrients intake, pounds per day.
DN′ = digestible nutrients apportioned to lactation, pounds.
DN″ = digestible nutrients apportioned to maintenance, pounds per day.
DN‴ = digestible nutrients apportioned to gain in weight, pounds.
y = DN minus DN‴
FCM = milk energy yield, pounds of 4 per cent milk per day. (= pounds milk per day × .4 + pounds fat per day × 15. Milk energy of one pound 4 per cent milk = 340 calories.)
W = average light weight, pounds.
△W = gain in live weight, pounds per day.
IW = live weight 3 days after calving, pounds. (Applied to FCM for the following 8 months, 243 days, as experimental period.)
D = observed y minus calculated y.
n = number of records.

actually indicated by the experimental data themselves. A special point of interest lies in the bearing of the working maintenance exponent on an energy-size index of lactation (2, 3, 4, 5, 6, 7, 8).

DATA AND METHODS

The data used here are taken from the convenient compilation published by Brody and Cunningham (9). The data are treated in various groups as indicated in Table 1. All the records are for mature cows, younger cows having been excluded to avoid complications of growth. Except for the 10 records of Forbes, the records used are the same ones used by Brody and Procter in deriving their equation $DN'' = .053W^{.73}$.

Following the general style of Brody and Procter, it is assumed that DN may be partitioned between FCM, W and $\triangle$W by the least-squares fitting of an appropriate equation to the experimental observations. It is desired to express working maintenance as a function of live weight in the form $DN'' = bW^c$, in which we are specially concerned with the evaluation of c or working maintenance exponent. A direct determination of c is not possible but an indirect first approximation by trial and error is attempted as follows.

It is assumed with Knott, Hodgson and Ellington (10) that a pound of gain in live weight corresponds to 3.53 pounds of digestible nutrients, and a pound of loss in live weight corresponds to 2.73 pounds of digestible nutrients. Accordingly, $y = DN - 3.53\triangle W$ for the $+\triangle$W's, and $y = DN - 2.73\triangle W$ for the $-\triangle$W's. That is, $y < DN$ for the $+\triangle$W's, and $y > DN$ for the $-\triangle$W's.

We now proceed to partition y between FCM and W by assuming that $DN' = aFCM$ and $DN'' = bW^c$ and hence $y = aFCM + bW^c$. This equation is fitted to the observed y's, FCM's, and W's by least squares, using trial values for c of 0, .15, .30, .45, .60, .73, .87, 1.00, 1.13, 1.27, 1.40, 1.70 and 2.00. From the corresponding equations, for each of the groups of records indicated in Table 1, ΣD^2 for each trial value of c is calculated as $\Sigma D^2 = \Sigma y^2 - a\Sigma FCMy - b\Sigma W^c y$. For any particular group of records the trial value of c giving the lowest value of ΣD^2 is taken to be the working maintenance exponent indicated for the particular group of records, since the corresponding equation reduces the sum of the squares of the differences between the observed and calculated values of y to a minimum and is therefore the least-squares fit, within limitations of the procedure. The equation constants, with related data, are given in Table 2.[2] Since b of itself is difficult of comprehension when c differs from 1 or 0 it is reported in Table 2 as

[2] To secure accuracy in ΣD^2 it is necessary to use more figures for a and b than given in the table. In the present work 8 significant figures have been used for a and b, as solved from the normal equations: $\Sigma(FCM)^2a + \Sigma(FCM)W^cb = \Sigma(FCM)y$ and $\Sigma(FCM)W^ca + \Sigma(W^c)^2b = \Sigma W^cy$.

TABLE 1

Number of records, by original source, breed of cow, and sign of ΔW

SOURCE OF DATA	GUERNSEY			HOLSTEIN			JERSEY			ALL BREEDS		
	$+\Delta W$	$-\Delta W$	$\pm\Delta W$	$+\Delta W$	$-\Delta W$	$\pm\Delta W$	$+\Delta W$	$-\Delta W$	$\pm\Delta W$	$+\Delta W$	$-\Delta W$	$\pm\Delta W$
Haecker	8*	8*	16*	16*	11*	27*	19*	36*	55*	43*	55*	98*
Forbes	0	0	0	7*	3	10*	0	0	0	7**	3	10**
Harrison	0	0	0	80*	23*	103*	0	0	0	80**	23**	103**
Savage	2	0	2	14*	0	14**	6	0	6	22*	0	22**
Hill	0	0	0	4	0	4	5	0	5	9*	0	9**
Eckles	0	0	0	2	0	2	5	0	5	7*	0	7**
Perkins	0	0	0	4	0	4	0	0	0	4	0	4
All Sources	10*	8**	18*	127*	37*	164*	35*	36**	71*	172*	81*	253*

* The records of each starred group are used to determine a first approximation of the working maintenance exponent. The double star indicates the group is a duplicate of a preceding group, reading normally.

$b1000^c$. The expression $b1000^c$ represents the pounds of digestible nutrients per day apportioned to working maintenance of a 1000-pound cow.

While ΣD^2 serves for any one group to indicate the least-squares fit with respect to c it is not comparable between groups where n is variable. On this account $\Sigma D^2/(n-2)$ is used, to allow for the number of records in the group, and for the two constants, a and b, in the equation as fitted. The values of $\Sigma D^2/(n-2)$ for the trial values of c are given in Table 3 and plotted in Figure 1.

TABLE 2

First approximation of the working maintenance exponent, c, in the Equation $y = aFCM + bW^c$ for the starred groups of Table 1; and related data

ORIGINAL SOURCE	BREED* OF COWS	SIGN OF $\triangle W$	n	MEAN OF W	RANGE** IN W	$\frac{\Sigma D^2}{n-2}$	a	$b1000^c$	c
Haecker	G	+	8	852	254	.711	.326	8.56	1.27
do	G	−	8	897	197	.531	.265	11.25	2.30
do	G	+ & −	16	874	254	.751	.287	9.70	1.40
do	H	+	16	1049	534	2.445	.053	15.05	.60
do	H	−	11	962	429	.668	.341	7.38	.73
do	H	+ & −	27	1013	534	2.070	.185	11.93	.45
do	J	+	19	858	336	.436	.255	8.85	.30
do	J	−	36	820	379	1.168	.259	9.91	1.00
do	J	+ & −	55	833	437	.959	.258	9.20	.60
do	GHJ	+	43	928	580	1.511	.208	10.73	.60
do	GHJ	−	55	860	639	1.070	.296	8.81	1.00
do	GHJ	+ & −	98	890	681	1.321	.259	9.54	.73
Forbes	H	+	7	1134	441	.030	.254	8.70	.60
do	H	+ & −	10	1131	541	.599	.368	4.81	1.27
Harrison	H	+	80	1278	372	.818	.297	9.00	.15
do	H	−	23	1285	346	.440	.268	11.17	.15
do	H	+ & −	103	1280	419	1.039	.308	8.96	.15
Savage	H	+	14	1129	356	1.274	.213	12.34	.45
do	GHJ	+	22	1046	529	1.307	.266	9.98	.73
Hill	HJ	+	9	1094	505	1.482	.413	5.86	.87
Eckles	HJ	+	7	966	512	.308	.428	4.99	.30
All Sources	G	+	10	873	307	.896	.247	9.89	.73
do	G	−	8	897	197	.531	.265	11.25	2.30
do	G	+ & −	18	884	307	.987	.274	9.51	1.00
do	H	+	127	1226	672	1.496	.292	8.93	.30
do	H	−	37	1176	656	.692	.269	9.85	.60
do	H	+ & −	164	1215	719	1.455	.301	8.57	.45
do	J	+	35	874	336	.678	.311	7.74	.45
do	J	−	36	820	379	1.168	.259	9.91	1.00
do	J	+ & −	71	847	437	.977	.291	8.30	.60
do	GHJ	+	172	1134	718	1.312	.303	8.27	.45
do	GHJ	−	81	990	866	.995	.293	8.66	.87
do	GHJ	+ & −	253	1088	866	1.311	.305	8.15	.60

* G = Guernsey; H = Holstein; J = Jersey.

** W for heaviest cow minus W for lightest cow.

TABLE 3

Values of $\Sigma D^2/(n-\bar{2})$ for the various trial values of c in the equation $y = aFCM + bW^c$ fitted by least squares to the records of the starred groups of Table 1. The black face figures indicate, for the particular group the best of the trial values of c, that is, the lowest $\Sigma D^2/(n-2)$

ORIGINAL SOURCE	BREED OF COWS	SIGN OF △W	TRIAL VALUE OF c												
			0	.15	.30	.45	.60	.73	.87	1.00	1.13	1.27	1.40	1.70	2.00
Harrison	H	+	.83	**.82**	.82	.84	.87	.91	.97	1.02	1.08	1.16	1.23	1.39	1.63
Harrison	H	−	.44	**.44**	.47	.55	.66	.78	.94	1.10	1.28	1.48	1.67	2.10	2.50
Harrison	H	+ & −	1.05	**1.04**	1.04	1.06	1.10	1.15	1.21	1.28	1.35	1.44	1.52	1.71	1.95
Eckles	HJ	+	.39	.34	**.31**	.32	.37	.46	.59	.75	.92	1.12	1.31	1.70	2.00
Haecker	J	+	.52	.46	**.44**	.45	.50	.61	.65	.75	.85	.97	1.08	1.33	1.56
All Sources	H	+	1.65	1.54	**1.50**	1.50	1.55	1.62	1.72	1.81	1.93	2.06	2.19	2.44	2.71
Savage	H	+	1.59	1.42	1.31	**1.27**	1.31	1.38	1.49	1.61	1.74	1.88	2.00	2.28	2.51
All Sources	J	+	.74	.70	.68	**.68**	.69	.74	.76	.81	.86	.92	.98	1.14	1.30
All Sources	GHJ	+	1.88	1.61	1.41	**1.31**	1.32	1.41	1.56	1.73	1.93	2.15	2.37	2.77	3.12
Haecker	H	+ & −	3.30	2.49	2.32	**2.07**	2.09	2.23	2.45	2.69	2.94	3.21	3.45	3.94	4.34
All Sources	H	+ & −	1.76	1.59	1.49	**1.46**	1.48	1.54	1.63	1.73	1.84	1.97	2.10	2.35	2.61
Forbes	H	+	.33	.19	.09	.04	**.03**	.05	.08	.12	.17	.21	.25	.34	.40
Haecker	H	+	4.26	3.54	2.94	2.55	**2.45**	2.61	2.99	3.48	4.04	4.64	5.18	6.26	7.06
Haecker	GHJ	+	2.55	2.18	1.86	1.62	**1.51**	1.57	1.66	1.86	2.10	2.39	2.66	3.22	3.67
All Sources	H	−	1.97	1.45	1.04	.79	**.69**	.71	.81	.93	1.08	1.24	1.39	1.71	2.00
Haecker	J	+ & −	1.25	1.13	1.04	.98	**.96**	.98	.98	1.01	1.05	1.10	1.16	1.29	1.42
All Sources	J	+ & −	1.22	1.12	1.05	1.00	**.98**	.98	.98	1.01	1.02	1.06	1.10	1.20	1.32
All Sources	GHJ	+ & −	2.32	1.94	1.61	1.40	**1.31**	1.34	1.45	1.60	1.77	1.97	2.15	2.50	2.79
Savage	GHJ	+	2.20	1.95	1.69	1.48	1.35	**1.31**	1.34	1.44	1.56	1.72	1.86	2.18	2.42
All Sources	G	+	1.52	1.35	1.18	1.04	.94	**.90**	.92	.99	1.11	1.27	1.44	1.82	2.10
Haecker	H	−	1.20	1.01	.85	.74	.68	**.67**	.68	.69	.72	.75	.78	.84	.92
Haecker	GHJ	+ & −	2.20	1.92	1.67	1.48	1.35	**1.32**	1.33	1.40	1.51	1.65	1.79	2.11	2.39
Hill	HJ	+	2.83	2.40	2.04	1.78	1.61	1.52	**1.48**	1.48	1.52	1.57	1.64	1.81	2.00
All Sources	GHJ	−	2.94	2.56	2.07	1.57	1.19	1.02	**.99**	1.07	1.19	1.35	1.49	1.78	2.01
Haecker	J	−	1.66	1.53	1.40	1.31	1.23	1.19	1.17	**1.17**	1.18	1.20	1.23	1.30	1.39
Haecker	GHJ	−	1.80	1.65	1.49	1.34	1.22	1.14	1.09	**1.07**	1.08	1.11	1.16	1.30	1.45
All Sources	G	+ & −	1.71	1.56	1.41	1.27	1.15	1.07	1.01	**.99**	.99	1.03	1.09	1.30	1.53
Haecker	G	+	1.94	1.71	1.48	1.26	1.06	.92	.81	.75	.71	**.71**	.72	.81	.93
Forbes	H	+ & −	1.28	1.25	1.17	1.05	.90	.78	.69	.64	.61	**.60**	.60	.62	.65
Haecker	G	+ & −	1.93	1.75	1.49	1.38	1.22	1.09	.97	.88	.81	.77	**.75**	.79	.90
Haecker	G	−	2.55	2.36	2.17	1.96	1.78	1.61	1.44	1.29	1.15	1.02	.90	.70	.58*

* The value of $\Sigma D^2/(n-2)$ decreases to .53 at c = 2.30, then increases to .56 at c = 2.60.

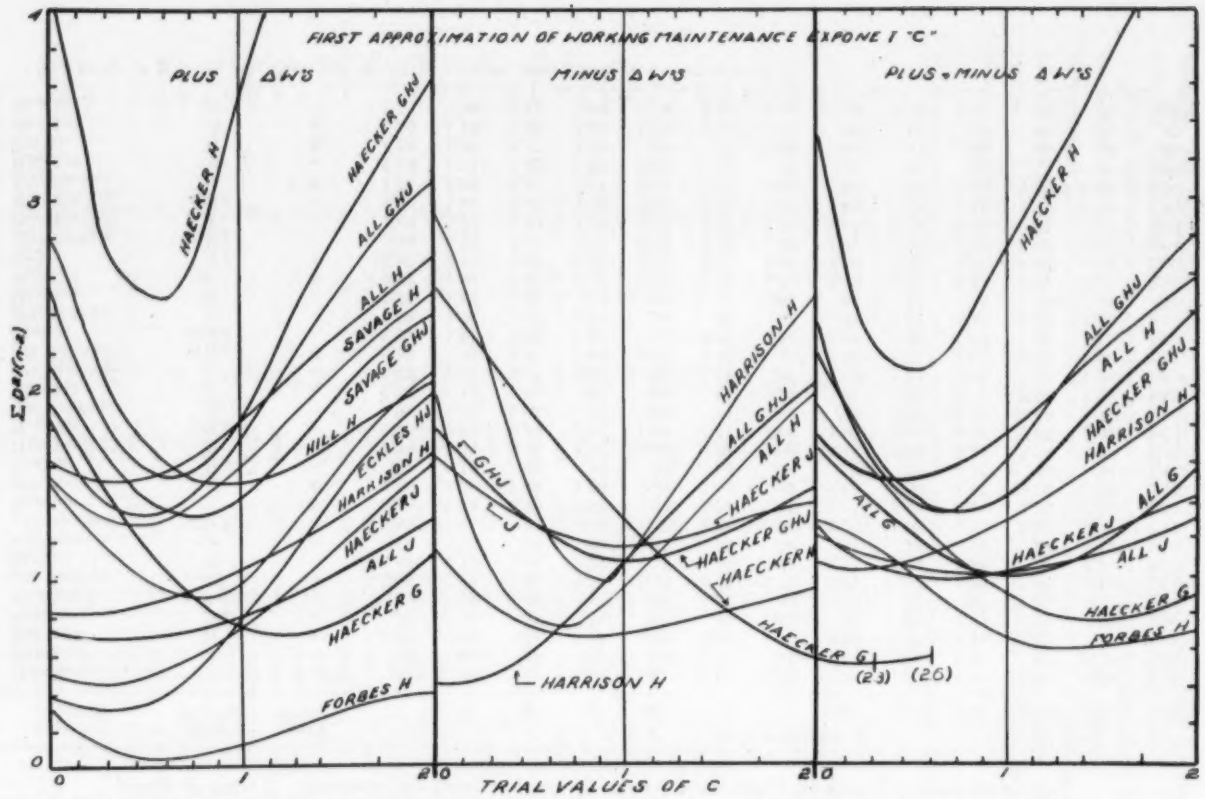

FIG. 1. Change in $\Sigma D^2/(n-2)$ with change in c for the starred groups of Table 1. The letters, G, H, J, indicate the breeds: G for Guernsey, H for Holstein, J for Jersey. The low point of any curve indicates for that particular group of records the best first approximation of the working maintenance exponent, c.

DISCUSSION OF DATA

The first step in the present estimate of the working maintenance exponent introduces the uncertainty of the allowance made for $\triangle W$. Brody and Procter treated $\triangle W$ as acting equally whether the cow gained in live weight ($+\triangle W$) or lost in live weight ($-\triangle W$) during the experimental period, and found $DN''' = 2.1\triangle W$. The present allowance is somewhat greater than this but is used in preference to $2.1\triangle W$ on the theory that for purposes of estimating DN′ or DN″ the nutrients used for a pound of gain in live weight cannot be recovered 100 per cent in a pound of loss in live weight. In any case, DN‴ is minor in magnitude as compared to DN′ or DN″. Nevertheless, the expression of DN′ as a function of FCM, and of DN″ as a function of W may be profoundly influenced by the physiological state represented by a cow gaining in weight as compared with that represented by a cow losing in weight during the experimental period of lactation. The present disposition of DN‴ is justified only to simplify the problem and make it workable as a first approximation in evaluating the constants for lactation and working maintenance.

Considering the 253 records in lump, Table 2 (last line) shows $DN' = .305FCM$, which agrees exactly with Brody and Procter's results; and $DN'' = .129W^{.60}$, in comparison with their $DN'' = .053W^{.73}$, which two equations give the same result for DN″ when W = 937, and do not differ by more than 8 per cent at other values of W from 600 to 1800. Furthermore, as may be seen from Table 3 or Figure 1 (curve marked "All GHJ," right-hand section) there is little choice between c = .60 and c = .73; while c = .73 is distinctly indicated in preference to c = 1.00. The lumped data, therefore, support the validity of Brody and Procter's working maintenance exponent .73 in preference to Haecker's exponent 1.00, or Morrison's (11) exponent .87.

When we examine the similar data for the various subgroups, great confusion develops. There are differences according to original source of the experimental data, according to breed of cow, according to sign of $\triangle W$. As to source, an item that may be important is the portion of lactation represented. Thus, Haecker's data are for periods varying in length from 7 weeks to 26 weeks, and somewhat variable as to stage of lactation. Harrison's data, on the other hand, are for either the 3d–37th weeks or 3d–40th weeks of lactation. As to breed, there are 18 Guernsey records, 164 Holstein records and 71 Jersey records. For all records lumped together, Holstein dominates by reason of numbers.[3] Throwing the breeds together should have an advantage, however, in providing greater range of live weight. As to sign of $\triangle W$, a possible difference in physiological state of the cow has

[3] The 164 Holstein records are in turn dominated by the 103 records of Harrison, which give the very peculiar result that working maintenance is proportional to $W^{.15}$, or substantially independent of live weight.

been noted. It should be noted further that $a - \triangle W$ does not mean that the cow was losing weight throughout the experiment; neither does $a + \triangle W$ mean that she may not have lost weight in the early stages of lactation. It might be better to apply the analysis to short periods of lactation, comparable as to stage of lactation and direction of change in live weight.

Considering the $172 + \triangle W$ records as a group, we find the best value of c to be .45. The various $+ \triangle W$ subgroups as given in Figure 1 (left-hand section) show considerable variation, but may be taken to indicate that working maintenance is proportional to the square root of live weight. It is difficult to accept this result as correctly representing working maintenance if we accept basal metabolism as proportional to $W^{.73}$. Working maintenance involves, for example, locomotion and the energy required for locomotion probably varies directly with W (rather than $W^{.73}$).[4] If basal metabolism is proportional to $W^{.73}$ we should expect working maintenance to be proportional to live weight to some power greater than .73. In these $172 + \triangle W$ records it is possible that lactation is forced by the pressure of a surplus of nutrients, and that under such conditions the assumption that $DN' = aFCM$ may involve a serious error.

Considering the $81 - \triangle W$ records as a group, we find the best value of c to be .87. The various $- \triangle W$ subgroups as given in Figure 1 (center section) show a great range in the best value of c – from Harrison's Holsteins ($c = .15$, with $c = 0$ equally acceptable) to Haecker's Guernseys ($c = 2.30$). Is this difference a matter of breed, stage of lactation represented, accident of sampling, or what? It may be noted that Haecker's $- \triangle W$ records for all breeds together support his working maintenance exponent 1.00. In fact, this is a fair compromise value for all the $- \triangle W$ subgroups of Figure 1.

The feeding standards illustrated in Figure 2 show considerable disagreement, one with another. Evidently the estimate of working maintenance from a practical feeding standpoint is not very exact or well established. It appears from the present analysis that it cannot be very consistently expressed as proportional to live weight to some fixed power. Perhaps some factor not closely associated with live weight plays a prominent part. Insofar as working maintenance can be expressed as a function of live weight there appears to be no need to depart from Haecker's simple expression,[5] $DN'' = .008W$.

[4] Distance of travel also enters into the energy of locomotion. Distance of travel may depend on individual disposition or, in the case of grazing animals, it may be related to W. The larger the cow the more herbage she will eat and the greater the distance she must travel in grazing, and since W thus enters twice into the equation it would tend to make the energy of locomotion vary as W^2.

[5] In view of the variability in the determined values of working maintenance it is permissible to round Haecker's .007925 into .008. Also, his coefficient, .327, for FCM may apparently be reduced to .3. The equation of his feeding standard then becomes $DN = .3FCM + .008W$.

BEARING ON AN ENERGY-SIZE INDEX

It would seem almost obvious that a record of size of cow should accompany the record of milk yield. Nevertheless, size records, in the form of live weight or linear dimensions of body, have been tried and abandoned by several breed associations in the course of development of their milk recording systems. This may be taken to mean that the importance of size of cow is evident by common observation, but as thus far used the size measurements have not served a very useful purpose. There is need to introduce size into the record in some practical and meaningful way.

Live weight has usually been estimated by eye, leading to inaccuracies. This situation could be improved by use of a chest girth measurement (in

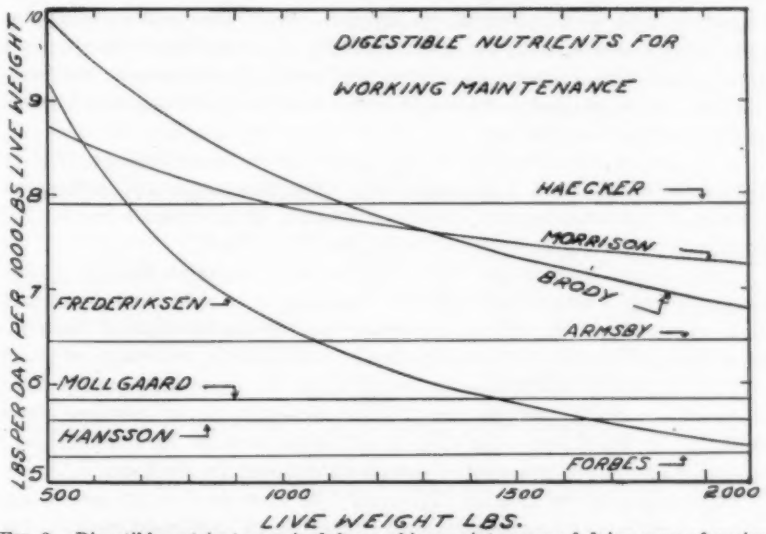

FIG. 2. Digestible nutrients required for working maintenance of dairy cows of various live weights, according to 8 different feeding standards.

the absence of scales) in estimating the live weight. Also, the live weights have been estimated at variable stages of lactation and gestation, which further impairs their usefulness in the problem of evaluating dairy merit of individual cows. The problem of a suitable biological measure of comparative dairy merit is complex. For present purposes we may examine four formulas based on milk energy yield and live weight of cow. Using symbols as above, page 583, the four formulas may be set up as follows:

$61FCM/(FCM+.173W^{.73})$	vs.	$155\ FCM/W^{.73}$	1 vs. 1a
vs.		vs.	vs. vs.
$53FCM/(FCM+.0242W)$	vs.	$1000\ FCM/IW$	2 vs. 2a

All these formulas may properly be regarded as energy-size indexes or efficiency formulas. Formula 1 is advocated by the Missouri Station (2, 3, 4) as an estimate of the percentage ratio of milk energy yield to digestible feed energy consumed, which ratio is regarded as "unquestionably the only proper index of physiologic dairy value" (9, p. 29). Formula 1a is suggested by Dr. Brody (correspondence) as an alternative to formula 1. After the general idea of Jordan (12) formula 2 was used by the writer (5) as an indirect estimate of efficiency to indicate the economic or social significance of annual milk energy yield per unit of live weight. It was later (6, 7, 8) modified to the simple and direct relation of formula 2a. In formula 2a it is considered essential to deal: A, with FCM for a suitable, uniform interval of the lactation period (such as the first 8 months of the lactation); and B, with initial live weight (IW). Prescription A applies with equal force to any biological measure of comparative dairy merit. Prescription B is designed to provide uniformity in taking live weights—at a very yield-significant stage of the reproductive cycle and in a manner readily workable in practice.[6]

In a general way, formulas 1, 1a, 2, and 2a are more like than unlike. But in technical detail and implication there are important differences. These may be brought out by numerical example, as in Tables 4 and 5. For simplicity it is considered that IW = W, that is $\triangle W = 0$.

Table 4 uses as example 1000-pound cows at variable FCM's or productive levels. Comparing formulas 2 and 2a it is clear that formula 2 tends to accentuate the difference between cows at low levels, and obliterate the difference between cows at high levels. As a direct expression of dairy merit it is clearly desirable, for instance, to recognize an increase from FCM = 80 to FCM = 100 at least as prominently as an increase from FCM = 20 to FCM = 40. On this count alone formula 2a must displace formula 2 as a direct measure of comparative dairy development.

Physiologically the relation represented by formula 2 or the percentage ratio of milk energy to digestible feed energy[7] is an incidental result of the

[6] In commercial use it may be necessary to take IW at the first visit of the tester after the cow freshens. (This system is under trial in a few Illinois Dairy Herd Improvement Associations at the present time.) Another object of using initial live weight is that it tends to discount the yield influence of fatness at calving. For example, if a given cow may weigh either 1000 pounds or 1100 pounds after calving, according to condition of flesh, and if in 1100-pound condition her FCM is 10 per cent greater than in 1000-pound condition, then formula 2a perfectly discounts fatness at calving. Still another object of using IW is that it tends to make formula 2a more independent of age of cow at calving than would W or $W^{.73}$. The use of IW ignores $\triangle W$, except as $\triangle W$ may be correlated with gain in weight during the preceding calving interval. However, $\triangle W$ may be of itself an important index of dairy merit in connection with the given environment (feed).

[7] In commercial use it is not practical to determine the actual digestible feed energy consumed by the individual cow, hence the attempt to estimate the ratio of milk energy to feed energy by formula 1 or 2. While this ratio is very significant from the artificial

more primary relation FCM/W represented by formula 2a. As a direct biological measure of dairy merit it is better to use the simple primary relation FCM/W in some form, such as formula 2a.

The comparison of formulas 1 and 1a is similar to that of formulas 2 and 2a.

In Table 5 we have to consider the proposition of dealing with IW or with $W^{.73}$. The examples show that, relatively, the use of IW favors the small cow while the use of $W^{.73}$ favors the large cow.

Formula 1a is based on the broad theory that, as between individual animals of any or all warm-blooded species, physiologic weight (13) or active tissue (in distinction from supporting or relatively inactive tissue) is proportional to $W^{.73}$; working maintenance (2) is proportional to $W^{.73}$; and (in the cow at least) udder size (14, p. 13) or potential milking capacity is proportional to $W^{.73}$. Formula 2a is based on the narrow theory that, for practical purposes, as between individual dairy cows within a live-weight range of 600 to 1800 pounds, each of these three items may be considered proportional to initial live weight (IW).

TABLE 4

Comparison of energy-size indexes, or efficiency formulas, when W = IW = 1000 and FCM is variable

FCM =	0	20	40	60	80	100
Formula 2a, 1000FCM/IW =	0	20	40	60	80	100
Formula 1a, 155FCM/$W^{.73}$ =	0	20	40	60	80	100
Formula 1, 61FCM/(FCM + .173$W^{.73}$) =	0	26	37	42	46	48
Formula 2, 53FCM/(FCM + .0242W) =	0	24	33	38	41	43

TABLE 5

Comparison of energy-size indexes, or efficiency formulas, when FCM/W is constant and W (= IW) is variable

W = IW =	600	800	1000	1200	1400	1600	1800
FCM =	12	16	20	24	28	32	36
Formula 2a, 1000FCM/IW =	20	20	20	20	20	20	20
Formula 1a, 155FCM/$W^{.73}$ =	17	19	20	21	22	23	23
Formula 1, 61FCM/(FCM + .173$W^{.73}$) =	24	25	26	27	27	28	28
Formula 2, 53FCM/(FCM + .0242W) =	24	24	24	24	24	24	24

FCM =	60	80	100	120	140	160	180
Formula 2a, 1000FCM/IW =	100	100	100	100	100	100	100
Formula 1a, 155FCM/$W^{.73}$ =	87	94	100	105	110	114	117
Formula 1, 61 FCM/(FCM + .173$W^{.73}$) =	47	47	48	49	49	49	50
Formula 2, 53FCM/(FCM + .0242W) =	43	43	43	43	43	43	43

standpoint of monetary economy it is of no particular significance from the natural standpoint of species economy. Welfare of the species requires only a very low efficiency in the sense of ratio of milk yield to total feed consumption or FCM/DN. One may question the propriety of calling a high value by any one of the four formulas a high physiological efficiency of the cow; it is rather a high parasitic activity of the mammary gland fostered by man for his own benefit.

The idea that active tissue is proportional to $W^{.73}$ comes from the observed interspecies relation that basal metabolism is proportional to $W^{.73}$. If active tissue is proportional to $W^{.73}$ it follows that the per cent of active tissue is $KW^{-.27}$, that is, the per cent of active tissue varies with W. To illustrate by numerical example, consider a geometric series for W with factor 1/13 (for convenience, since $13^{.27} = 2$) starting with W = 1690 (cow) and running to W = 10/169 (mouse). Assume in the cow that the amount of body protein, 16 per cent of live weight as found by Moulton (15) is the amount of active tissue. The per cent of active tissue in the 1690-pound cow is then 16, or $119W^{-.27}$. The series becomes:

Illustrative animal	Cow	Goat	Cat	Rat	Mouse
Live weight, pounds, W	1690	130	10	10/13	10/169
Per cent active tissue $119W^{-.27}$	16	32	64	128	256

Does a goat have two times as high a percentage of active tissue as a cow, and does a mouse have sixteen times as high a percentage of active tissue as a cow? The active tissue interpretation of basal metabolism is clearly untenable.[8] It would seem more logical to think that the per cent of active tissue is substantially the same and that rate of activity varies.

Moulton (15) found in cattle the amount of body nitrogen (excluding contents of digestive tract) and the amount of blood to be each a constant percentage of live weight through a wide range of live weights. Body protein and blood volume are two very significant criteria of active tissue and support the use of formula 2a or FCM/IW rather than formula 1a or $FCM/W^{.73}$.

Whether working maintenance is in fact proportional to IW as contemplated by formula 2a or proportional to $W^{.73}$ as contemplated by formula 1a is not clear. Comparing a 1690-pound cow and a 130-pound goat, it seems reasonable to think that the active tissue of each constitutes the same per cent of live weight but that in the goat the rate of activity of the active tissue is twice as great as in the cow, under conditions of complete rest and fast. But that is not to say that the rate of activity continues to be twice as rapid in the goat as in the cow when this minimum metabolism is superseded by the metabolism of locomotion, heavy feed consumption, and heavy work connected with lactation, aside from the work of lactation itself. In other

[8] If we project the series down to a bacterium weighing 10^{-10} mg. we reach the result of 2,000,000 per cent active tissue. While this takes us out of the realm of warm-blooded animals it serves to emphasize the inherent difficulty in expressing the weight of any portion of an organism as proportional to a fractional power of the weight of the whole organism. Thus, by the .73 power philosophy, if the blood of a cow constitutes 5 per cent of her weight the blood of a mouse constitutes 16×5, or 80 per cent, of its weight. Carman and Mitchell (16) have heretofore pointed out that it is absurd to consider the protoplasmic content of animals to be proportional to surface area or the 2/3 power of weight.

words, the fact[9] that basal metabolism is proportional to $W^{.73}$ does not mean that working maintenance must also be proportional to $W^{.73}$. So far as present evidence on working maintenance goes it seems that formula 2a or FCM/IW is justified.[10]

The question of potential milking capacity as proportional to W *vs.* proportional to $W^{.73}$ is likewise not clear in answer. If we attempt to answer it by finding the regression of FCM on W by statistical analysis of various groups of records of live weight and yield, we get results varying from FCM independent of W to FCM directly proportional to W or IW. For example, the results (unpublished) from certain Red Danish records indicate a small negative correlation between chest girth and annual (fiscal year) yield. On the other hand, the records of Harrison (18, 19) indicate that FCM is almost directly proportional to IW, and the energy-size index, FCM/IW, is substantially independent of initial live weight ($r = -.02 \pm .11$ in the 1930–31 experiments, and IW = 1062 to 1534).

As a general proposition, however, most records indicate FCM to be proportional to some fractional power of W, perhaps as low as .5, or even lower. The philosophy of formula 1a or $FCM/W^{.73}$ expects more of the large cow than she is now customarily doing, that is, to bring her FCM up to $K_1W^{.73}$; while the philosophy of formula 2a or FCM/IW carries the expectation still further, up to K_2IW. Any rigorous experimental demonstration of the soundness of either formula 1a or 2a is hardly possible. As before suggested, the philosophy of formula 2a or FCM/IW rests on the conception that in highly bred dairy cows the upper limitation of lactation lies in the sheer work of the energy transformations; the possible work of energy transformation is proportional to the size of the cow machine; the size of the cow machine may be adequately measured in a practical way by initial live weight; the work of lactation is proportional to milk energy yield; hence, FCM/IW measures the degree to which the upper limitation of lactation

[9] The presentation of basal metabolism by Brody, Procter, and Ashworth (17) in their figure 1 to unite many species, from mouse to elephant, in size, by the concise (although empirical) equation $Q = 39.5W^{.734}$ is very impressive, to say the least. It may be noted that such an interspecies equation depends primarily on the mean values of basal metabolism and live weight for each of the several species, and does not necessarily have to hold as between individuals within a species.

[10] The use of live weight in estimating efficiency of milk production is much more simple than its use in estimating efficiency of meat production, because in meat animals the product accumulates in the body for long periods and complicates the situation. If a cow with initial weight of 1000 pounds were to accumulate 10,000 pounds of milk in her body (!), or 1300 pounds of milk solids, during the first 8 months of lactation, an estimate of efficiency from IW as in formula 2a would not be justified. It is probable that initial live weight is normally not far from average live weight for the whole calving interval, perhaps about as close as any single point that could be selected, except for first-calf heifers.

has been attained in the individual cow machine. When lactation reaches the stage of FCM = KIW, formula 2a gives simply DN/IW = Constant (except for changes in live weight).

By the above reasoning small cows are now more highly developed than large ones and the room for improvement is potentially greater in large cows than small ones. On the other hand, "It is much harder to develop a good large cow than it is to develop a good small cow."[11]

SUMMARY AND CONCLUSIONS

Certain records (253) of feed intake, milk yield, and change in live weight give on analysis, $DN'' = .129W^{.60}$, where DN″ is pounds of digestible nutrients per day for working maintenance and W is live weight of the cow, in pounds. Of these 253 records, 172 show a gain in live weight and give $DN'' = .369W^{.45}$; 81 show a loss in live weight and give $DN'' = .021W^{.78}$. It is thought the latter group best warrants the method of analysis. It is concluded the results of the whole analysis are too variable and uncertain to be regarded as necessitating any change in Haecker's $DN'' = .008W$, for dairy cows in milk.

If it is accepted as fact that basal metabolism = $KW^{.73}$, the question is raised as to the soundness of assuming that, consequently, active tissue

[11] The quoted statement was made by Dr. Yapp in discussing the development (breeding, feeding, care) of Illini Nellie as brought out by her "world's record" (20). By formula 2a this cow has an energy-size index of 51 (that is, daily milk energy yield for the first 8 months of lactation = 51 pounds of four per cent milk per 1000 pounds initial live weight), the highest of any cow in the herd under the present practice of uniform, suitable environment; she is also the largest Brown Swiss cow in the herd. The three items, 1000FCM/IW = 51, IW = 1690, and fat percentage = 4.02, give a significant summary of her dairy development for the given lactation and environment. It is held that as between individuals in a large population of highly bred dairy cows (any breed or breeds, age or ages) under good conditions of management, these three items are mutually independent. It is recognized that in the present stage of development of dairy cattle a negative correlation between IW and FCM/IW will appear in many instances. It is held that this is not inherent in the possible development, but rather represents the greater difficulty (genetic and environmental) of fully developing the potenialties of the large cow, as compared with the small one; and also, the lesser necessity of doing so from the standpoint of monetary profit per cow per year (9). As the yield of dairy cattle is developed from the present, say $FCM = K_1W^{.5}$, to the possible $FCM = K_2IW$ of formula 2a, we shall frequently find a more or less close approximation to $FCM = K_3W^{.73}$. Relatively, $FCM = K_2IW$ is a difficult goal for the larger cows and the dairyman whose pasture and feed conditions are abundant enough to be adapted to large cows may profitably (9) use them, even at a lower rating by formula 2a. The record should include size of cow in absolute terms, in addition to its use in an efficiency formula. To fit his particular individual condtions the dairyman may want a large cow or he may want a small cow, he may want a high-fat-percentage cow or he may want a low-fat-percentage cow, but he always wants a cow of high efficiency as gauged by formula 2a or FCM/IW.

$= K_1 W^{.73}$ working maintenance $= K_2 W^{.73}$, or potential milking capacity $= K_3 W^{.73}$.

The bearing of the working maintenance and live weight relation is discussed in comparison of four energy-size indexes or efficiency formulas. For practical utility as a biological measure of comparative dairy development preference is expressed for the formula FCM/IW in which FCM is milk energy yield for some suitable uniform period (such as the 3d–245th days) of the lactation, and IW (initial weight) is live weight of the cow at the start of the period.

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OXIDIZED FLAVOR IN MILK

V. THE EFFECT OF METAL-DEVELOPED OXIDIZED FLAVOR ON THE IODINE NUMBER OF THE MILK FAT

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It is generally believed that the oxidation of milk fat occurs at the double bonds of the unsaturated fatty acids. For this reason any appreciable oxidation of milk fat, as the result of oxidized flavor development in milk, might be expected to cause a reduction of its iodine number. In fact such reductions already have been reported by Kende (7) and by Dahle (2). Kende, after showing that milk fats extracted from milk with ether showed the same iodine numbers as those prepared by separation, churning and rendering, proceeded to prepare the fats by the ether extraction method. His results showed iodine number decreases of between 10.5 and 32.4 per cent as the result of the artificial production of oxidized flavor through the use of 4 mg. of metal (presumably copper) per liter. He found reductions of iodine number, as the result of spontaneous development of oxidized flavor, of between 11.9 and 14.1 per cent. Dahle, in a progress report which does not give any actual data, has stated that the iodine number decreases in proportion to the degree of flavor present.

When the authors made an incidental check of the effect of oxidized flavor development in milk on the iodine number of its fat the results were at such variance with those reported by Kende that the experiment herein reported was conducted.

EXPERIMENTAL

Collection and Preparation of Samples

All of the milk used in this experiment was from cows known to be producing milk that was susceptible to oxidized flavor development. The milk was drawn into aluminum pails and poured directly into a ten-gallon aluminum can, omitting the usual straining operation because the strainers available at the time this work was done had exposed copper surfaces which came in contact with the milk that was passed through them. The milk was brought to the laboratory immediately and pasteurized at 143 $\pm$ 1° F. for 30 minutes. Pasteurization was accomplished by immersing the can in water in a vat fitted with a cold water inlet, a steam coil for heating, and an overflow pipe. The milk was agitated by means of a glass rod. Approximately 20

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minutes were required to raise the milk to pasteurization temperature and 30 minutes were required to lower the temperature of the milk to 50° F. following the holding period.

When the milk had been cooled it was thoroughly stirred and divided equally between two aluminum cans by pouring. One of the cans had copper added to it in a concentration of 1.3 parts per million from a solution of copper sulphate, whereas the other served as a control. Both cans were immersed in ice water, and then stored in a cold room at 40° F. ± 5° for three days. This procedure had been shown previously to produce an oxidized flavor in milk contaminated with copper.

At the end of the storage period both samples were removed from the cooler, and flavor determinations were made by tasting. They were then warmed to 100° F. and separated. Each sample then was subjected to the following procedure. The cream was divided into two lots, half of it being cooled and churned in a small glass churn and the remainder being washed by repeated dilution with water at 115° F. ± 5° and then reseparated until the fat "oiled off." This usually required from 14 to 20 separations. Butterfats prepared in this way have been found to be free from phospholipids (9). The fats from the butteroils and from the samples of butters were

TABLE 1

Iodine number determinations on replicate samples of one fat

TRIAL NO.	IODINE NO		AVERAGE	
	26.8			
1	26.9		26.9	
	26.9			
	27.1			
2	26.8		26.8	
	26.5			
	26.8			
3	26.7		26.8	
	26.8			
	26.9			
4	27.0		27.0	
	27.0			
	27.1			
5	27.0		27.0	
	26.9			
	26.9			
6	26.9		26.9	
	27.0			
	Lowest	26.5	Lowest	26.8
	High	27.1	High	27.0
	Difference	0.6	Difference	0.2

placed in Hart casein tubes, melted in a water bath at 110–120° F., and centrifuged in an electrically heated Babcock centrifuge for 15 minutes. After centrifuging, the fat was transferred to dry sample bottles by decantation, care being taken not to pour off any water or curd collected in the base of the tube. The samples then were ready for iodine number determination.

Determinations on Replicate Samples

In order to find the amount of variation which normally could be expected in replicate determinations the iodine number of one fat was determined in triplicate in each of six individual trials. The results are shown in Table 1.

The widest variation between any two determintions was 0.6 of a unit, while the widest variation between the means of any two triplicate trials was 0.2. These results indicate that the iodine numbers of any two individual samples must differ by at least 0.2 to 0.6 of a unit before any difference in the degree of saturation of the fats would be indicated.

Determination of Iodine Numbers of Experimental Samples

The iodine number was determined in seven series of experimental samples during the latter part of 1935 and the early part of 1936. The values are shown in the first part of Table 2. The results of this experiment show quite conclusively that there was no decrease in iodine number when oxidized flavor was produced.

Because these results were at variance with those reported by Kende and by Dahle, it was decided that the experiment should be repeated about a year later. The same technique used the previous year was employed except that the iodine numbers were determined in duplicate by another worker who had no knowledge as to the identity of the samples. The results are shown in the latter part of Table 2. Here, also there was no measurable difference between the fats from oxidized and normal milks as shown by the iodine number. It would have been desirable to have had iodine number determinations on samples of fat from milk which spontaneously became oxidized in flavor, without the addition of copper, but unfortunately there were no cows in the Experiment Station herd producing such milk.

DISCUSSION

The authors are unable to explain the direct contradiction of Kende's results and Dahle's report shown by these experiments. It seems possible that an oxidized flavored milk which becomes very strongly oily might have had its butterfat oxidized, whereas, in a mildly oxidized flavored milk, the oxidation may have affected only the substance or substances of the adsorbed layers on the fat globules as postulated by the authors in previous publications (9) (10). Occasionally small dosages of copper added to milks of individual cows in the Station herd have caused development of strongly oily

TABLE 2

Iodine numbers of fat from butter and butteroil from milk showing oxidized and normal flavor

DATE	FAT FROM BUTTER				FAT FROM BUTTEROIL				FLAVOR OF OXIDIZED SAMPLE*
	Flavor				Flavor				
	Normal		Oxidized		Normal		Oxidized		
	Determination	Average	Determination	Average	Determination	Average	Determination	Average	
12/25/35	26.6 26.6 26.8	26.7	26.8 26.9 27.0	26.9	26.8 26.7 26.8	26.8	26.4 26.4 26.9	26.6	3
12/26/35	26.7 26.8 26.9	26.8	26.7 26.6 26.6	26.6	26.9 26.7 26.8	26.8	27.0 27.2 27.4	27.2	4
12/27/35	26.8 26.8 26.3	26.6	26.9 26.8 26.8	26.8	27.2 27.0 26.9	27.0	26.9 26.8 27.1	26.9	3
12/28/35	27.7 27.6 27.7	27.7	27.7 27.7 27.7	27.7	27.8 28.0 27.9	27.9	27.7 27.5 27.5	27.6	3
12/29/35	27.4 27.4 27.7	27.5	27.7 27.5 27.5	27.6	27.3 27.4 27.6	27.4	27.5 27.7 27.6	27.6	4
12/30/35	28.4 28.4 28.3	28.4	28.3 28.4 28.4	28.4	28.1 28.1 28.1	28.1	28.3 28.3 28.4	28.3	4
1/1/36	27.4 27.4 27.3	27.4	27.4 27.4 27.3	27.4	27.3 27.2 27.2	27.2	27.4 27.5 27.3	27.4	4
2/17/37	29.8 29.8	29.8	30.0 29.9	30.0	29.7 29.6	29.7	29.6 29.6	29.6	3
2/18/37	29.9 30.1	30.0	30.3 30.2	30.3	30.0 30.0	30.0	29.9 29.8	29.9	4
2/20/37	28.9 28.9	28.9	29.2 29.3	29.3	29.5 29.4	29.5	29.2 29.3	29.3	3
2/21/37	28.9 28.8	28.9	28.9 28.8	28.9	28.5 28.4	28.5	28.7 28.8	28.8	4
2/22/37	29.0 29.0	29.0	29.1 29.3	29.2	29.3 29.3	29.3	29.0 29.0	29.0	4

* Meaning of symbols: 3, moderate oxidized flavor; 4, fairly pronounced oxidized flavor.
Note: No oxidized flavor in normal samples.

flavors. Such milks may have been available to Kende and to Dahle for their work, but only moderately oxidized flavor developed in the milks studied in the experiments herein reported.

Because a finding that iodine numbers of milk fat decrease as oxidized flavor develops would indicate an oxidation of the fat itself it would seem fair to draw analogies with results relating to butter. Thus, although it has been shown by Greenbank and Holm (3), and others, that tallowy flavor does not become evident in the butterfat until after the end of the induction period and the beginning of rapid, logarithmic oxygen absorption, yet Henderson and Roadhouse (4) have found that the milk fat of oxidized flavored milk had passed only a fraction of its induction period. If we add the results of Holm and Greenbank (5) showing that the iodine number of butterfat did not change appreciably during oxidation until after the end of the induction period, and indeed not until after considerable oxygen had been absorbed, it would appear that oxidized flavor development in milk should not be expected to cause a change in the iodine number of its fat unless the oxidation had progressed considerably further than was the case with the milks studied by Henderson and Roadhouse.

The question arises, if the milk fat is not the constituent oxidized when mild or moderate oxidized flavor occurs, what constituent is oxidized? The previous work of the authors (9) (10) has indicated that the lecithin of the adsorbed layers on the fat globules is the constituent affected. However, other substances in the fat globule adsorbed films should not be overlooked. There is a possibility that cephalin may contribute to this behavior since the substance obtained from dry buttermilk and referred to as lecithin in the previous work (8) without doubt was a mixture of at least lecithin and cephalin.

If lecithin were the constituent oxidized it would be impossible to detect a change in iodine number as a result. Assuming that the lecithin molecule contains as the two fatty acid radicals one molecule of oleic acid and one molecule of stearic acid, the molecular weight was calculated to be 805. Since oleic acid has one double bond it would absorb 2×126.93 or 253.86 grams of iodine per mole of lecithin present. On this basis the calculated iodine number of lecithin would be 31.54, $\left(\frac{253.86}{805} \times 100 = 31.54\right)$. Horrall (6) gives the average lecithin content of fat from sweet cream butter as 0.232 per cent. But the lecithin in the butter replaced fat which in the case of the latter experiments had an iodine number of approximately 29.00. Butterfat with 0.23 per cent lecithin would have a calculated iodine number of 29.01.

According to this calculation an increase of only 0.01 of a unit of iodine number could be expected from the presence of 0.23 per cent lecithin in the sample. In this calculation it was assumed that lecithin contained only one

double bond capable of taking up iodine; if, however, lecithin contained as many as ten double bonds its oxidation still could not be determined by means of iodine numbers under the present conditions of accuracy of the method, and the small proportion of lecithin present in butterfat.

SUMMARY

In twelve trials during winter months of two successive years no measurable change in the iodine number of milk fat could be found as the result of the development of moderate or fairly pronounced oxidized flavor. It is shown by calculation that oleo-stearo lecithin in quantities usually found in sweet cream butter could not affect a measurable change in iodine number even though the double bonds of the oleic acid were completely oxidized. The evidence that the milk fat itself is not affected when oxidized flavor develops indicates that some other constituent of milk is the one in which the off-flavor arises when moderate to fairly pronounced oxidized flavor is produced.

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THE ELECTROKINETIC POTENTIAL OF MILK FAT[1]

II. RELATION TO DAIRY PROCESSES

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The repulsive force, or lack of it, among fat globules resulting from the electrokinetic potential at the surface has often been mentioned as an important factor in certain dairy processes in which clustering or aggregation of globules is important. The experiments described in this paper were planned to show the importance of this factor in such dairy processes.

HISTORICAL

The formation of a maximum cream layer on bottled milk is a matter of much commercial importance as is well known. The advent of commercial pasteurization introduced many problems connected with the effect of heat on the creaming ability of milk. It is generally recognized that the usual pasteurizing temperatures of market milk are not detrimental to creaming, but they represent the upper limits before reduction of creaming occurs. Babcock and Russell (1) in 1896, and Farrington and Russell (2) in 1899, were among the first to recognize this fact. Dahlberg and Marquardt (3) (4) have presented an excellent review of work in this field. The work of several investigators, and in particular Troy and Sharp (5), has shown that clustering of fat globules is essential to rapid and exhaustive creaming. The failure of fat globules to cluster in milk which has been heated above a certain point results in a reduction in the cream volume.

It remains to be shown what factors are important in promoting or preventing clustering. Palmer and Anderson (6) have shown that addition of milk albumin which increased the viscosity of the milk plasma accelerated creaming, while the addition of casein inhibited creaming. Rahn (7) suggests that this is caused by the heat inactivation of the sticky colloidal layer surrounding the fat globule. Sirks (8) found no apparent relation between creaming and the electrokinetic potential of the fat. In contrast to this, Dahlberg and Marquardt (3) have offered an explanation embracing an alteration in the magnitude of the charge on the particles. Numerous attempts by Hammer (9), Troy and Sharp (5), and others to promote clustering by altering the zeta potential through additions of electrolytes have been effective.

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EXPERIMENTAL

Creaming of Milk

Three series of experiments were made. In series 1 whole milk was heated to different temperatures with some of it held for 30 minutes and some of it cooled after 15 seconds, table 1. In series 2 skim milk was heated similarly and raw cream added after cooling to make a four per cent milk, table 2, and in series 3, 60 per cent cream was heated in the same manner and raw skim milk added after cooling to make a four per cent milk, table 2. Samples were held at 38° F. in creaming cylinders for 24 hours at which time the cream volumes were measured. The readings are expressed as cream volume percentage per one per cent fat content of the milk. Electrophoretic mobilities of the fat globules were determined by the method described in a previous paper (10).

TABLE 1

The effect of heating whole milk (series 1) on cream volume and electrophoretic mobility of the fat globules

TEMPERATURE °F.	TIME HELD	CREAM VOLUME/ % FAT	MOBILITY μ/SEC/V/CM.
	min.		
Unheated	----	4.01	2.56
110	30	3.98	2.56
120	30	3.86	2.57
130	30	4.06	2.55
140	30	3.90	2.68
150	30	2.50	3.15
160	30	0.62	3.52
	sec.		
110	15	4.06	2.55
120	15	3.91	2.57
130	15	4.04	2.56
140	15	4.01	2.54
150	15	3.91	2.60
160	15	3.23	2.75
170	15	0.72	2.92
180	15	0.69	3.04

The writers are aware of the possibilities of irregularities resulting from applying a relatively high heat to small quantities of cream, and any tendency toward inconsistency in the results is explained on that basis.

It was observed in these experiments that when the cream volume was reduced by the heat treatment the cream layer which formed was higher in fat than when the creaming was normal. Table 4 shows the results of a typical experiment in the relation between cream volume and fat content of the cream layer.

TABLE 2

The effect of heating skim milk on cream volume and electrophoretic mobility

TEMPERATURE °F.	TIME HELD	CREAM VOLUME/ % FAT	MOBILITY μ/SEC/V/CM.
	min.		
Unheated	.....	4.10	2.55
110	30	4.00	2.56
120	30	4.05	2.57
130	30	3.90	2.55
140	30	3.75	2.54
150	30	1.80	2.56
160	30	1.20	2.55
	sec.		
120	15	3.95	2.54
130	15	4.00	2.55
140	15	4.00	2.55
150	15	4.05	2.53
160	15	1.05	2.56
170	15	0.50	2.54
180	15	0.50	2.55

TABLE 3

The effect of heating cream on cream volume and electrophoretic mobility

TEMPERATURE °F.	TIME HELD	CREAM VOLUME/ % FAT	MOBILITY μ/SEC/V/CM.
	min.		
Unheated	.....	4.00	2.56
110	30	4.05	2.55
120	30	3.80	2.55
130	30	3.80	2.54
140	30	3.60	2.61
150	30	3.70	3.05
160	30	3.85	3.55
	sec.		
120	15	4.05	2.56
130	15	3.94	2.57
140	15	3.80	2.55
150	15	3.80	2.55
160	15	4.05	2.56
170	15	3.85	2.67
180	15	3.90	3.05

The results of series 1 in which whole milk alone was heated show that the first reduction in creaming occurs above 140° F. when the milk is held for 30 minutes at this temperature. This is the usual observation in commercial practice. Accompanying the cream reduction in this case is a corresponding increase in electrophoretic mobility. In the same series where the holding period was 15 seconds, the decrease in creaming and increase in mobility

TABLE 4

The relation between heat reduction of creaming and the fat content of the cream layer

TEMPERATURE °F.	TIME HELD	CREAM VOLUME/ % FAT	TEST OF CREAM %
	min.		
Unheated	....	4.10	23.4
110	30	3.95	23.9
120	30	4.00	23.8
130	30	4.00	27.5
140	30	3.85	29.0
150	30	2.70	34.4
160	30	0.70	46.8

occur at temperatures somewhat under the pasteurization point. This can be explained by the fact that under commercial conditions the heating is almost instantaneous while under the experimental conditions an appreciable time interval elapsed. The results of this series show a decrease in creaming ability and an increase in electrophoretic mobility at temperatures above those used for the vat method of pasteurization.

The results obtained in series 2 where skim milk was heated and raw cream later added show a more marked reduction in creaming at temperatures above the pasteurization point. However, there is no alteration in the electrophoretic mobility of the fat globules. In series 3 where cream was heated and then mixed with raw skim milk, reverse conditions of series 2 resulted; the electrophoretic mobility of the fat globules was increased without a significant decrease in cream volume. This refutes the argument that the increase in the electrokinetic potential of the fat globules is the chief factor in the heat destruction of creaming because the creaming ability of the milk is reduced in the one case without change in the potential, and conversely in the other case the potential is increased without change in the creaming ability.

Furthermore, a consideration of the type of cream layer formed when the creaming ability is reduced by heat reveals the fact that it is different from that expected if the increase in electrokinetic potential were the controlling factor. The argument has been advanced that the increased potential increases the repulsive force among the globules and prevents clumping, thus resulting in a more shallow cream layer. If this were true, the cream layer formed would be lower in fat content than one formed under normal conditions because of the repulsion among the globules. Contrary to this, the opposite condition results in which the cream layer formed, when heat has reduced the creaming ability, has a higher fat content than where normal creaming has taken place. From these data, it appears that alteration in the electrokinetic potential of milk fat globules is not a major factor in heat reduction of creaming.

Homogenization

It is known that homogenization of milk or cream subdivides the fat globules in such a way that under some conditions the resulting smaller particles are grouped together in clumps, and under some conditions the clumps are broken up so that the particles are uniformly dispersed. Sommer (11) states that ice cream mixes which show the greatest degree of clumping are the most viscous and have the poorest whipping ability. Doan (12) calls attention to the fact that in homogenized dairy fluids the protein stability decreases with increasing fat clumping. Sommer again offers the theoretical explanation for the clumping tendency based on the idea that increased clumping is related to a decrease in the electrical charge on the homogenized fat particle. Mohr and Brockmann (13) found that homogenization had no effect on the value of the isoelectric point of the fat globules in whole milk.

It is the general observation that single stage homogenization at 150° F. is conducive to clumping of fat globules and dual homogenization at the same temperature tends to inhibit clumping. In this study whole milk and two samples of cream of different fat contents were used. Each was heated to 150° F. and divided into two portions. One portion of each was homogenized with a single valve under 2000 pounds pressure and the other portion was homogenized by dual homogenization using 2000 pounds pressure on the first valve and 500 pounds pressure on the second valve. Samples were examined for clumping and electrophoretic mobility. The results are shown in Table 5.

TABLE 5

The effect of homogenization on clumping of fat globules and electrophoretic mobility

LOT NO.	FAT PER CENT	POUNDS PRESSURE		GLOBULE SIZE MICRONS	DEGREE OF CLUMPING	MOBILITY μ/SEC/V/CM.
		Single	Double			
1	4.2	2000	0	1.5	+	2.65
2	4.2	2000	500	1.5	–	2.68
3	21.0	2000	0	1.5	+++	2.65
4	21.0	2000	500	1.5	–	2.65
5	36.0	2000	0	2.0	+++	2.65
6	36.0	2000	500	1.5	–	2.64

In lots 3 and 5 the clumps averaged about 20 microns in diameter and migrated with the same velocity as the individual globules. The mobilities of the globules correspond to those of normal milk heated to 150° F. It is apparent that the degree of clumping is independent of the electrophoretic mobilities of the globules.

SUMMARY AND CONCLUSIONS

Cream volume studies and electrophoretic mobility measurements of fat globules were made on milk heated to different temperatures in the following manner: whole milk heated, skim milk heated and raw cream later added to

make a four per cent milk, and cream heated and skim milk added later to make a four per cent milk.

The creaming ability was reduced when whole milk and skim milk were heated separately above the pasteurization point. The creaming ability was not affected when cream alone was heated and made into four per cent milk with raw skim milk.

The electrophoretic mobility of fat globules was increased when whole milk and cream were heated above the pasteurization point. The mobility was not affected when skim milk was heated and made up with raw cream.

The fat content of the cream layer increased as the cream volume was reduced by heat.

Neither single stage homogenization accompanied by fat clumping nor double stage with no clumping of fat globules had any effect on the electrophoretic mobility of the fat globules.

The electrokinetic potential is not an important factor in the creaming of pasteurized milk.

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CHEMICAL CHANGES IN THE MAKING OF A.I.V. ALFALFA SILAGE AND NUTRITIVE QUALITIES OF MILK PRODUCED THEREFROM[1]

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LITERATURE REVIEW

Numerous papers have appeared in recent years regarding the preservation of plant forages by ensiling them with mineral acids. The most widely used of these methods is known as the A.I.V. method and reports regarding its use have come from both foreign and American investigators (1–15). In general the claim that forages, especially legumes, ensiled by this method show less loss of protein, carotene and total nutrients than untreated forage appears to be well substantiated. The development of a butyric type of fermentation with its accompanying production of ammonia and objectionable odors is prevented by acidifying the plant tissue to a pH of about 3.5. At this low pH a lactic type of fermentation takes place with but little decomposition of protein.

In a previous publication (14) experiments were reported dealing with the fermentative changes, the preservation of protein and carotene, and the effect upon cows of feeding alfalfa ensiled by the A.I.V. method. Because of the variable conditions encountered in silage making, it was considered advisable to repeat the previous experiments and to enlarge upon certain phases of them. Greater emphasis was placed upon the study of the fermentative changes in the silage and upon certain aspects of the feeding trials. In order to throw some light on the fermentative changes as well as to study the progressive changes in nitrogen distribution and carotene content, several small lots of silage were preserved in barrels with and without the addition of acid.

PART I. PREPARATION AND COMPOSITION OF SILAGE

Preparation and Analysis.—Forty-two tons of alfalfa were ensiled in June, 1934, in the same silo and in the same manner as the second lot of alfalfa described in our previous publication. The alfalfa was pitched into

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[1] Cooperative experiment by the Departments of Agricultural Chemistry, Animal Husbandry, and Agricultural Bacteriology. Various phases of the work have been done with the advice or supervision of Professors G. Bohstedt, C. A. Elvehjem, E. B. Fred, E. B. Hart, I. W. Rupel, and H. Steenbock, and with the analytical assistance of Messrs. H. C. Greene, A. F. Langlykke, L. S. McClung, and F. W. Quackenbush. Credit is due Mr. G. M. Werner for direct supervision of the feeding of the cows and collection of the milk samples. Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

[2] Now at College of Agriculture, University of Idaho, Moscow.

the top of the silo from an elevated driveway without being cut up, and 100 liters of 2N acid, containing 40.2 lbs. of commmercial HCl (18° Be) and 7.9 lbs. of commercial H_2SO_4 (65° Be), were added to each ton of green forage. In our previous experiment 120 liters of acid were required but the alfalfa used in the present experiment was longer stemmed and more succulent than that put up in the preceding year.

When the silo was full, 100 cc. of an emulsion of mustard oil (allyl-isothiocyanate) was added with the last portion of acid, and the silage was covered with tar paper, shavings, and soil as recommended by Virtanen and as described in our earlier paper. The drainage juice was collected as previously described.

The fresh plant material and silage were analyzed for dry matter, total nitrogen, total water soluble nitrogen, amino nitrogen, ammonia nitrogen, and carotene as in the previous work. Determinations of fermentation products by methods already described (16) and numbers of bacteria by counts on glucose yeast-extract agar plates were also made on the silage twice during the emptying of the silo.

At the time that the silo was filled six barrels were filled with some of the same alfalfa. For this purpose the alfalfa was chopped in a silage cutter. Acid was added to five of the barrels in the same proportion as to the contents of the silo, and the sixth barrel was left as a control with no acid. The barrels were carefully packed full of the chopped alfalfa, headed up, and sealed with paraffin. The barrels containing A.I.V. silage were opened after intervals of 5, 12, 23, 37, and 155 days, respectively. The control barrel was also opened after 155 days. Determinations of the number of microorganisms, the fermentation products formed, and the changes in carotene content were made on the contents of all the barrels, and in the case of the control barrel and the last two barrels of acidified silage to be opened, nitrogen distribution was also studied.

RESULTS AND DISCUSSION

There was considerably less drainage from the silo in this experiment than in the preceding one. In 1933 the volume of drainage was 1,480 liters containing the equivalent of 237 liters of 2N acid, or 11.4 per cent of the 2,075 liters of 2N acid added in the preparation of the silage. In 1934 the volume of drainage was 1,640 liters containing the equivalent of 218 liters of 2N acid or 5.1 per cent of the 4,280 liters of 2N acid added in the preparation of the silage. That only about half as much acid ran out in the second experiment as in the first probably was due to the smaller quantity added and to a greater amount of drying of the alfalfa in the field. Drainage was reduced also by adding less than the calculated quantity of acid to the first 3 loads of alfalfa put into the silo.

Table I summarizes some of the changes occurring in the alfalfa. In

TABLE I

Analyses of green alfalfa and A.I.V. alfalfa silage

	PLANT MATERIAL	SILAGE	
		After 6½ months. Near top of silo	After 11 months. Near bottom of silo
pH		3.6	3.5
Dry matter, per cent	25.5 – 38.0	28.5	30.0
Total nitrogen, dry basis, per cent	2.80	2.69	2.87
Water soluble nitrogen			
Dry basis, per cent	0.76	1.53	1.81
Basis of total N, per cent	27.1	56.8	63.1
Amino nitrogen			
Dry basis, per cent	0.35	0.71	0.87
Basis of total N, per cent	12.4	26.3	30.4
Ammonia nitrogen			
Dry basis, per cent	0.013	0.14	0.28
Basis of total N, per cent	0.46	5.3	9.7
Carotene, dry basis, micrograms/gm.	90	156	117
Volatile acids, as acetic, dry basis, per cent		1.67	2.24
Non-volatile acids, as lactic, dry basis, per cent		5.84	5.27
Lactic acid, dry basis, per cent		1.17	3.04
Alcohol, as ethyl, dry basis, per cent			0.70

general these changes are the same as those observed in the previous experiment except that there was an increased formation of ammonia. In the work previously reported the ammonia nitrogen constituted from 0.2 per cent to 1.0 per cent of the total nitrogen in fresh plant material and from 1.0 per cent to 1.7 per cent of the total nitrogen in the silage, while in this experiment the ammonia nitrogen made up 0.46 per cent of the total nitrogen in the fresh alfalfa, and 5.3 per cent and 9.7 per cent of the total in the two samples of silage analyzed. The latter figure was obtained on a sample taken from near the bottom of the silo and might very easily have been affected by drainage downward of ammonia. The figures for water soluble nitrogen and amino nitrogen were also higher in this sample, though the difference was less marked than in the case of the ammonia. It is difficult to explain this increased ammonia formation, since the pH was at the desired level throughout the silo, except for one figure obtained on a sample taken from near the top at the time the silo was opened. The pH at this point was 4.0, and there was a layer several feet thick of partially spoiled material at the top. As stated above, the alfalfa was very coarse and long-stemmed, and this fact may have slowed the process of settling and packing of the silage and so allowed this spoilage at the top. The increased ammonia content lower down may have been another manifestation of delayed settling and packing or it may have been the result of downward drainage of ammonia

from the spoiled material at the top. As in the previous experiment, there was a substantial increase in water soluble nitrogen and amino nitrogen over the amounts found in the fresh plant material, but these increases do not, of course, necessarily represent losses in feeding value, since much of the water soluble and amino nitrogen may be available to the animal. The figures for carotene, as in the preceding year's work, were distinctly higher in the silage than in the fresh alfalfa, but, as will be explained later, it is doubtful that these increases represent carotene.

In general the data on fermentation agree with the data obtained in the previous experiment. The amount of non-volatile acid was considerably greater than the amount of volatile, but probably only the lactic part of the non-volatile acid was of fermentation origin. The other part of the non-volatile acid probably consisted of citric, malic and other plant acids. The alcohol content of the silage was approximately that formed in corn silage (17).

The presence of large numbers of bacteria during the ensiling period is indicated by the presence of these fermentation products. Direct evidence on this point was obtained by plate counts of the silage taken about one foot below the surface in order to avoid the presence of any organisms growing on the surface or deposited from the air. Samples were taken several times during the feeding period and gave counts of about 20 million per gram of silage. Such numbers do not give any indication of the maximum popula-

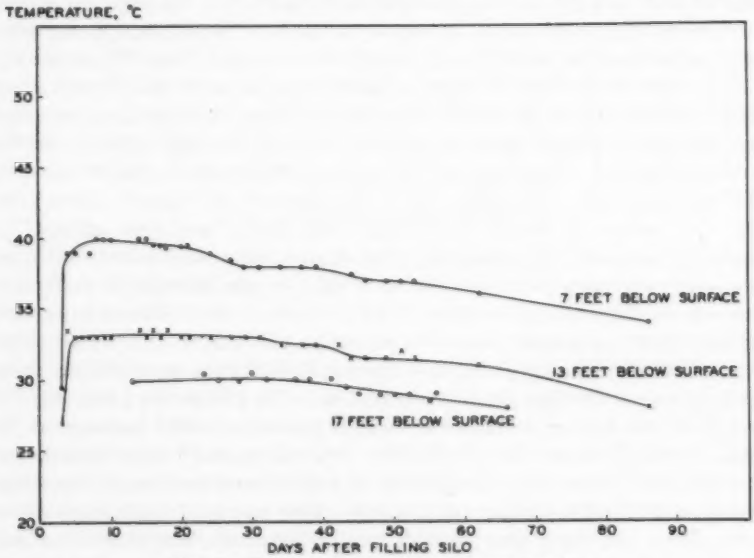

FIG. 1. TEMPERATURE CHANGES IN THE SILAGE.

tion at the height of fermentation but only those that persist after most of the fermentation is over and conditions have become more or less stable. From data on the barrel silage, populations equal to 200 million per gram were found in the early stages of fermentation.

Figure 1 shows the temperature changes at three different levels in the silo. At levels seven feet and thirteen feet below the surface there was a very quick rise in temperature followed by a slow decrease. Temperatures were higher at higher levels in the silo, the maximum being 40° C. seven feet below the surface, 33½° thirteen feet below, and 30½° seventeen feet below. This inverse relation between temperature and depth was found by Peterson, Hastings, and Fred (17) to obtain also in the formation of corn silage. The alfalfa was put up during a period of very hot weather and therefore the green forage was warm at the time it went into the silo. Cell respiration was also high and was probably not checked by the added acid before the temperatures recorded had been reached.

TABLE II
Data on Barrel Experiments

	PLANT MATERIAL	A.I.V. SILAGE		ENSILTED WITHOUT ACID AFTER 5 MONTHS
		After 5 weeks	After 5 months	
pH	.....	3.7	3.67	5.20
Dry matter, per cent	25.5	24.2	22.9	21.8
Total nitrogen, dry basis, per cent	2.80	2.65	2.51	2.69
Water soluble nitrogen				
Dry basis, per cent	0.76	1.41	1.32	2.04
Basis of total N, per cent	27.1	53.1	52.6	75.8
Amino nitrogen				
Dry basis, per cent	0.35	0.80	0.66	1.06
Basis of total N, per cent	12.4	30.1	26.2	39.4
Ammonia nitrogen				
Dry basis, per cent	0.013	0.16	0.17	0.69
Basis of total N, per cent	0.46	6.04	6.70	25.6
Carotene, dry basis, micrograms/gm.	90	200	184	126
Volatile acids, as acetic, dry basis per cent	.....	2.80	3.96*	7.75**
Non-volatile acids, as lactic, dry basis, per cent	.....	5.85	4.62	3.16
Lactic acid, dry basis, per cent	.....	2.27	2.40	0.70
Numbers of bacteria, millions/gm. dry matter	.....	36	480	1040

* Acetic, 84%, butyric 16%.
** " 49%, " 51%.

In Table II the data on the barrel experiments are summarized. The nitrogen distribution in the two barrels containing acid was much the same as in the silo and there were apparently no very significant changes between

the times that the two barrels were opened. A comparison of the figures for the two barrels containing acid with those for the control barrel shows very strikingly the effect of the acid in the preservation of the proteins. Even though the figures for ammonia nitrogen are rather high for the A.I.V. silage, they are small in comparison to that for the control barrel, in which one-quarter of the total nitrogen was in the form of ammonia. The figures for water soluble nitrogen and amino nitrogen are also relatively high in the control barrel, being respectively 75.8 per cent and 39.4 per cent of the total nitrogen, whereas in the two barrels of A.I.V. silage they were, in the case of the water soluble nitrogen, 53.1 per cent and 52.6 per cent of the total and in the case of amino nitrogen 30.1 per cent and 26.2 per cent of the total.

There appeared to be a progressive increase in carotene which is not shown in this table. The barrel opened after 12 days showed a carotene content of 109 micrograms per gm. as compared with the 90 micrograms per gm. in the fresh plant material. After 23 days this figure had increased to 150 and after 37 days to 200. The figure of 184 micrograms per gm. obtained after 155 days or 5 months is, in view of the difficulties in sampling, not very different from the figure 200. As reported in our previous paper, acid treatment of green alfalfa over a short period of time (12 hours) increased very markedly the apparent carotene content. In many cases this increase amounted to about 50 per cent. It is probable that the slow increase observed in the barrel experiments was due to the same cause. The carotene values of the A.I.V. silage must therefore be taken with a good deal of reservation. Nevertheless because of the high carotene and vitamin A content of the milk produced from this silage it appears that the carotene was well-preserved but that there was an actual increase seems doubtful.

The data on fermentation show that such fermentation as occurred in the acidified silage was of a more desirable type than that occurring in the non-acidified. Volatile acids were very high in the latter, being 7.75 per cent on the dry basis as compared with 2.80 per cent and 3.96 per cent for the two barrels of A.I.V. silage. Conversely, lactic acid was less than one-third as high in the control barrel as in the other two. There apparently was an increase in volatile acids and a decrease in non-volatile acids between the times the two barrels of A.I.V. silage were opened. As the lactic acid did not change materially, it appears that the other non-volatile acids, presumably of plant origin, were slowly destroyed during the fermentation. Bacterial counts made on glucose yeast-extract agar plates indicated that there was a progressive decrease in the number of organisms during the first 5 weeks, but there appeared to be an increase later. The barrel opened after 5 days contained 760 million organisms per gm. of dry matter. After 12 days there were 640 million, after 23 days 264 million, after 37 days 36 million, and after 155 days 480 million. In the control barrel after 155 days there were 1,040 million organisms per gram of dry matter. It is of interest to note that

even at such low pH values as 3.5–3.7 growth of lactic acid-forming bacteria is not inhibited.

PART II. EFFECT OF FEEDING A.I.V. SILAGE ON THE NUTRITIVE VALUE OF THE MILK

This experiment was conducted to study further the effect of A.I.V. alfalfa silage over a five months period of feeding, on the nutritive value of the milk, with special reference to the carotene and vitamin A content of the butterfat.

Fourteen dairy cows were chosen from the University herd and divided into two lots of seven cows each, approximately equal in total milk and butterfat production, live weight, period of lactation, and breed. Each lot consisted of three Holsteins, one Brown Swiss, one Guernsey, one Jersey, and one Ayrshire. Lot 1, the check lot, was fed a grain mixture of corn 50 parts, oats 40 parts, linseed oil meal 10 parts, steamed bone meal 1 part, and iodized salt 1 part, plus alfalfa hay and corn silage. The cows were fed one pound of grain for every 3½ pounds of milk produced and one pound of hay and three pounds of corn silage per 100 pounds of live weight. Lot II, the A.I.V. lot, received a grain mixture of corn 50 parts, oats 50 parts, steamed bonemeal 2 parts, and iodized salt 1 part, plus timothy hay and A.I.V. silage. Grain was fed at the same rate as in Lot I, hay at one-half the rate in Lot I, and A.I.V. silage was given *ad libitum*. One ounce of $CaCO_3$ was fed per ten pounds of A.I.V. silage to neutralize the excess acid. By making the change gradually no difficulty was experienced in getting the cows to eat the new type of silage.

Besides the above fourteen cows one Guernsey and one Holstein cow were fed the check ration for a long time, five months, and were then changed to the A.I.V. silage ration. The reversal feeding periods eliminated individual differences among cows and the long feeding period on the check ration, it was expected, would accentuate the effect of the A.I.V. silage on the changes in the milk.

Composite milk samples were collected from each lot at monthly intervals by compositing one quart of milk from each cow at the morning and evening milkings. The butterfat was prepared as previously described and analyzed spectroscopically for carotene and vitamin A (18, 19).

Since our previous comparison (14) of the A.I.V. silage with pasture was not made with the same cows or immediately after A.I.V. feeding, a direct comparison of these two feeding stuffs was made. A Guernsey and a Brown Swiss, which had been fed A.I.V. silage for 150 days, were changed to blue grass pasture as the principal source of roughage. Individual butter samples were analyzed after 19 and 38 days of pasture feeding.

To compare A.I.V. alfalfa silage with green alfalfa, an Ayrshire and a Jersey taken from the A.I.V. lot were fed respectively 39 pounds and 49 pounds of freshly cut green alfalfa daily for six weeks. These quantities of green alfalfa were equivalent to the same dry matter content as was contained

in the A.I.V. silage consumed by these cows. At the beginning of the feeding period the alfalfa was somewhat less mature and at the end somewhat more mature than that used for making the acid silage. The average stage of growth, however, was approximately the same in the two experiments. The dry matter content was determined weekly on the green alfalfa and A.I.V. silage to asure an equal dry matter intake. Individual samples of butter were prepared and analyzed as before.

To study the growth promoting quality of the milk produced under different feeding conditions, properly prepared male rats were fed the various milks fortified with iron, copper, and manganese. Salts of these elements were added to the milk so as to give each rat .5 mg. of Fe, .05 mg. of Cu and .05 mg. of Mn daily. The animals were fed the milk *ad libitum* and consumption records were obtained by measuring back the unconsumed milk. The animals were kept in individual wire bottom cages and were weighed weekly. Composite samples of milk from Lots I and II as well as individual samples from cows 4, 5, 6, 7 were tested. The milks from cows 6 and 7 were tested when they had been on the respective rations for two months and again after four months. The milk from cow 4 was tested a third time, after she had received green alfalfa for four weeks. This milk was compared with milks from two other cows that were receiving either green alfalfa or pasture.

To determine whether the rats were receiving sufficient vitamin A, the livers of three rats from each group on the Jersey milks were analyzed. The vitamin A determinations were made on the unsaponifiable extracts by means of the Carr-Price technique (20). A solution of $SbCl_3$ in chloroform saturated at 0° was used as a reagent and readings were made on the Lovibond tintometer. The results were calculated according to the method of Moore (20).

RESULTS AND DISCUSSION

Carotene and Vitamin A Content of Milks

The data in this experiment are in accord with the results obtained in our previous work (14). The continuous feeding of A.I.V. alfalfa silage during the winter months (December–April) maintained a milk higher in both carotene and vitamin A than ordinary winter milk (Figure 2). There was a greater increase in the vitamin A than in the carotene content of the milk which is explainable in view of the fact that Holstein, Brown Swiss, and Ayrshire breeds predominated in each group, and these breeds are known (19) to convert a large percentage of their carotene into vitamin A. The maximum effect of A.I.V. silage was reached within the first 30 days of feeding, and then there was a slight drop to a value which was maintained at a nearly constant level during the remaining part of the experimental period. Our previous study presented the same condition, which suggests that there is some physiological adjustment on the part of the animal to a large increase in carotene intake. Watson, Bishop and Drummond (22) observed the same condi-

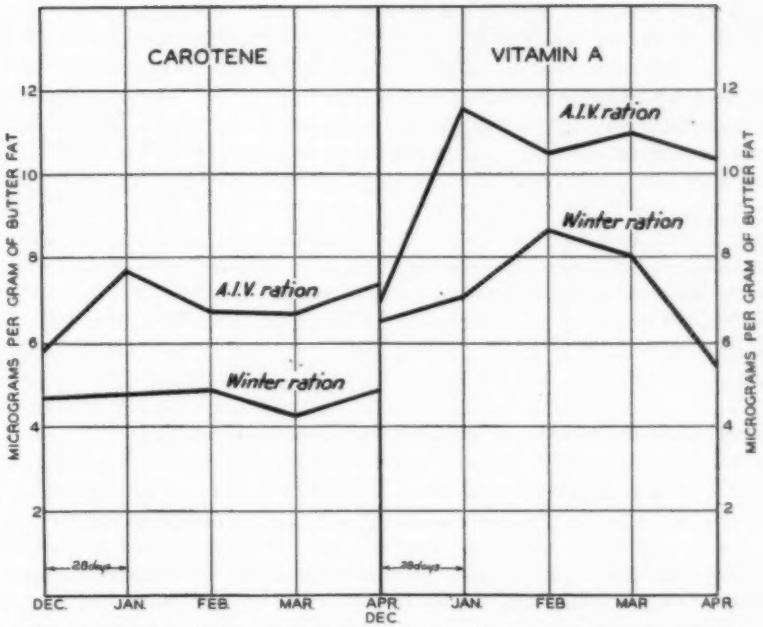

FIG. 2. EFFECT OF RATION ON THE CAROTENE AND VITAMIN A CONTENT OF BUTTERFAT.

tion in their experiments and designated this upper level as a "ceiling" value above which the color and vitamin A content of the butterfat does not rise regardless of the quantity of carotene ingested.

A direct comparison of A.I.V. silage with pasture indicated that butterfat produced on pasture contained from 50 to 100 per cent more carotene and from 30 to 45 per cent more vitamin A than that produced on A.I.V. silage (Table III). Several reasons may account for the fact that pasture is more effective than A.I.V. feeding. First, the carotene intake is no doubt higher because of a larger consumption of green material containing more carotene, and second, the acid treatment of green tissue may change the carotene into an isomeric form that is utilized less efficiently. A recent study in this laboratory has shown that there is a distinct difference in the availability of carotene in various roughages in rations of dairy cows.

Further support of the superiority of fresh green plant tissue to A.I.V. silage was revealed by feeding an Ayrshire and a Jersey green alfalfa on the same dry weight basis as A.I.V. silage had previously been fed for 150 days (Table III). At the end of six weeks of green alfalfa feeding a marked increase was noted in both the carotene (about 50 per cent) and vitamin A (34–103 per cent) content of the butterfat. Although there may have been

TABLE III

Comparison of A.I.V. alfalfa silage with pasture and green alfalfa as to their effect on the Vitamin A content of butter fat

BREED	COW NO.	DAYS ON RATION	RATION	BUTTERFAT	
				Carotene	Vitamin A
				micrograms per gram	*micrograms per gram*
Guernsey	1	150	A.I.V. silage	12.7	6.2
Guernsey	1	19	Pasture	18.5	7.5
Guernsey	1	38	Pasture	19.7	9.0
Brown Swiss	2	150	A.I.V. silage	5.6	7.9
Brown Swiss	2	19	Pasture	13.0	9.4
Brown Swiss	2	38	Pasture	10.4	10.1
Ayrshire	3	150	A.I.V. silage	2.8	8.3
Ayrshire	3	14	Green alfalfa*	3.3	13.7
Ayrshire	3	42	Green alfalfa*	4.4	16.9
Jersey	4	150	A.I.V. silage	7.8	6.5
Jersey	4	14	Green alfalfa*	8.5	7.8
Jersey	4	42	Green alfalfa*	11.6	8.6

* Green alfalfa was fed on the same dry matter basis as A.I.V. alfalfa silage.

a difference in the quantity of carotene ingested, such large increases suggest that the carotene in green alfalfa is more effectively utilized than that in A.I.V. silage.

TABLE IV

Growth-promoting quality of various milks

	COW NO.	BREED	RATION	AVERAGE GAIN PER RAT IN 6 WEEKS
Composite milks	Lot I	Several	Winter	153
	Lot II	Several	A.I.V. silage	161
Individual milks				
March series	5	Jersey	Winter	122
	4	Jersey	A.I.V. silage	137
	6	Holstein	Winter	141
	7	Holstein	A.I.V. silage	158
May series	6	Holstein	Winter	142
	7	Holstein	A.I.V. silage	161
	3*	Ayrshire	Green alfalfa	162
	4	Jersey	Green alfalfa	162
	8*	Holstein	Pasture	155
Reversal series	16	Guernsey	Winter	116
	16	Guernsey	A.I.V. silage	136
	17	Holstein	Winter	156
	17	Holstein	A.I.V. silage	168

* No. 3 had previously been on the A.I.V. silage ration and No. 8 on the check ration.

The results obtained from the studies on the growth promoting properties of the milks produced on the different rations are summarized in Table IV. It is readily evident that the composite samples of milk from both groups gave good growth. If these results are compared with those obtained in 1933–34 (14) we find that this year (1934–35) the results for both the check lot and the A.I.V. lot are equal to those for the A.I.V. group the previous year. This difference cannot be due to any variation in the rats used for assay because milk from other cows on a winter ration fed to similarly prepared rats gave the characteristically poor growth. The only logical conclusion is that the cows in the check lot were receiving in their ration sufficient amounts of the factor or factors in question to render the milk more complete. This lot received alfalfa hay which we know varies in its ability to produce milk of different growth-promoting properties. In spite of the high quality of the milk from the check lot the milk from the A.I.V. group showed somewhat better growth properties.

More marked differences were obtained from studies on individual milks. The results with those from cows 16 and 17 deserve particular attention as the reversal method of feeding was used with these animals and hence differences between individuals were eliminated. Increased gains of from 12 to 20 gm. per rat were observed for the A.I.V. milks. Attention is also called to the greater growth on winter milks of low fat content, *i.e.*, Holstein, than on those of higher fat content, *i.e.*, Jersey and Guernsey. Rats consumed more of the former to satisfy their energy requirement and at the same time ingested more of the growth factor.

That the difference in growth-promoting quality of the two winter milks was not caused by a lack of vitamin A in the control group was shown by the ample storage of this vitamin in the livers of the animals receiving this milk (Table V). Although rats receiving A.I.V. milk stored more vitamin A than animals receiving the control milk, a storage of vitamin A equivalent to 359 blue units per rat liver indicates an abundant supply of this factor in the

TABLE V

Vitamin A storage in rats on winter and A.I.V. milk

LOT	MILK	NUMBER OF RAT	WEIGHT OF RAT	WEIGHT OF LIVER	TOTAL BLUE UNITS PER LIVER	BLUE UNITS PER GRAM OF LIVER
			gm.	*gm.*		
	Winter	56	226	12.0	374	31.2
I	Winter	57	194	10.4	341	32.8
	Winter	59	182	9.7	363	37.4
				average	359	
	A.I.V.	68	222	7.5	473	63.1
II	A.I.V.	69	218	9.0	550	61.1
	A.I.V.	72	208	9.5	440	46.3
				average	488	

diet. Calculation of the vitamin A intake gave further evidence of the adequacy of the supply. Milk consumption was over 50 cc. per rat per day or slightly over 2 gm. of butterfat. From the data in Figure 2 it can be seen that this quantity of butterfat contained nearly 10 micrograms of carotene and about 15 micrograms of vitamin A. Such an intake of carotene and vitamin A is probably several times the daily requirement even for maximum growth.

SUMMARY

Alfalfa ensiled by the A.I.V. method showed large gains in amino and soluble nitrogen but only small increases in ammonia nitrogen. The carotene value increased but it is doubtful that the increase represents carotene.

Bacteriological platings showed large numbers of microorganisms (10–200 million per gm. of silage) to be present at various times during the fermentation. The production of volatile acids, ethyl alcohol and lactic acid indicated that microorganisms similar to those present in corn silage were active. When the alfalfa was ensiled without the addition of acid, enormous numbers of bacteria developed, and produced large quantities of ammonia and butyric acid.

Feeding of A.I.V. alfalfa silage to dairy cows through the winter months produced a milk with 50 per cent more carotene and 40 per cent more vitamin A than milk produced on a well-balanced winter ration.

Butterfat from cows on pasture contained from 50 to 100 per cent more carotene and about 30 per cent more vitamin A than butterfat produced from A.I.V. silage.

Green alfalfa fed on the same dry weight basis as A.I.V. silage also increased the vitamin A potency of the butterfat over the A.I.V. values.

Rats fed on mineralized milk produced by cows fed A.I.V. alfalfa grew more rapidly than rats fed mineralized winter milk. There was no appreciable difference in the growth of rats fed milk produced from A.I.V. silage, green alfalfa, or pasture.

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ABSTRACTS OF LITERATURE ON MILK AND MILK PRODUCTS

BACTERIOLOGY

319. The Part of the Lactic Acid Streptococci in the Formation of Aroma in Starters. J. Van Beynum and J. W. Pette. Report for 1935 of the Experimental Dairy Farm, Hoorn, Holland, pp. 205–235, 1936 (English summary)

The authors find that typical butter aroma is diacetyl produced by fermentation of citric acid by lactic streptococci and aromabetacocci.

Studies of *Streptococcus cremoris* and *Streptococcus lactis* for starters indicated that one organism did not give a distinct advantage over the other as excellent starters could be made with suitable strains of either bacterium in conjunction with aromabetacocci. This was substantiated by a study of 63 strains of lactic acid bacteria isolated from starters, sour milk, cheese, and whey.

Two new species were found, described, and named *Streptococcus aromaticus* and *Streptococcus citrophilus.* A.C.D.

320. The Rydzewski Standard Loop Colony Count. George S. Rydzewski, Blochowiak Dairy Co., Milwaukee, Wisconsin. Milk Dealer *26*, 6, p. 42, March, 1937.

The author describes a test which shows a direct relationship between the non-heat-resisting and heat-resisting bacteria. The test also tends to show the number of bacteria present in both raw and pasteurized milks, the percentage destruction by pasteurization, and the type and character of bacterial colonies.

The milk is measured and streaked on the surface of set agar in square petri dishes. As many as four samples may be streaked on one plate

C.J.B.

BUTTER

321. A Study of the Body and Texture of Butter. S. T. Coulter and W. B. Combs, Dairy Div., Univ. of Minn., St. Paul, Minn. Minn. Agr. Exp. Sta. Tech. Bul. 115, Sept., 1936.

Data are presented showing the effect of variations in the manufacturing procedure on the hardness, spreadability, standing up properties, and appearance of butter as examined with a trier. The hardness of butter was found to be increased by cooling the cream to a low temperature, churning at a low temperature and using relatively warm wash water. The spreadability of butter was improved by the use of those practices which decreased the hardness of the butter. The standing up properties of butter were

increased by thorough cooling of the cream, churning at a low temperature and the use of wash water at a moderate temperature.

The authors recommend that winter butter be manufactured making use of those procedures which decrease the hardness of butter. Where these practices were followed, spreadability of the butter was much improved and a "sticky-crumbly" characteristic which is very common in butter produced during the winter in that locality was largely eliminated.

For the manufacture of summer butter the use of those practices which increase the hardness of butter is recommended. S.T.C.

322. Preventing "Sticky-Crumbly" Butter. S. T. COULTER AND W. B. COMBS, Dairy Div., Univ. of Minn., St. Paul, Minn. Minn. Agr. Exp. Sta. Extension Folder 60, Feb., 1937.

A brief discussion of some of the practical aspects of the material presented in Minnesota Exp. Sta. Tech. Bul. 115, 1936. S.T.C.

Other abstracts of interest are numbers 319, 326, 328, 364, and 365.

CHEESE

323. The Cheese Yielding Capacity of Milk and Its Relation to the Method of Payment for Milk for Cheesemaking. F. H. MCDOWALL, Dairy Rsh. Inst., Palmerston North, N. Z., pp. 10364, 1936.

A satisfactory payment for milk must be based upon the percentages of butterfat and casein in milk. These may be determined by the Babcock and Walker Methods. Such systems of payment as fat, fat plus casein, fat plus 2, etc. are not correct as payment should be based on calculated cheese yields.

Cheese yields per hundred of milk vary not only with the fat and casein percentages but also with losses of fat in the whey, casein losses in the whey, ash, salt, and moisture content of the cheese. Shrinkage in storage and pasteurization of the milk which slightly increases the yield. The cheese yields, milk and cheese composition data were carefully determined at many New Zealand factories.

It was found that the Gerber tests made in the laboratory were .06 per cent higher than the Roese-Gottlieb results. The Babcock tests made in the factories were .045 per cent lower than the Gerber tests made in the laboratory.

The percentage of casein as determined by the Walker method agreed on an average with .016 per cent in the factory and the laboratory. The Walker tests were but slightly higher than those made by the A.O.A.C. method. The variations in calculated cheese yields due to analytical errors were considered.

The yield of cheese, when 14 days old, based upon Walker casein and the fat could be calculated by the equation:

yield per 100 lbs. milk = 2.08 C + 1.19 F

Using casein or total protein percentages as determined by A.O.A.C. methods, the equations were:

yield per 100 lbs. milk = 2.42 C + .98 F

yield per 100 lbs. milk = .167 P + 1.14 F

The cheese made for these trials, 785 vats of milk, contained 34.9 per cent water and 54.7 per cent of fat in the dry matter when 14 days old. The shrinkage during the first two weeks storage was 1.54 per cent of the weight of the green cheese.

The "casein plus fat" in milk and its relation to cheese yield was found to be:

(Walker), yield per 100 lbs. milk = 1.33 (C + F) + 1.42

(A.O.A.C.), yield per 100 lbs. milk = 1.20 (C + F) + 2.29

The fat/Walker casein ratio was 4.31/2.488 or .577. This ratio varied widely for individual vats of milk and increased during drought.

In conclusion the author recommends the payment for milk for cheese-making on the "costed cheese" system. The milk would need to be tested for casein by the Walker method (the only practical method) and for fat. Cheese yields would be calculated for each patron from the casein/fat ratio. Payment would be based upon the calculated cheese delivered and its value less cost of manufacture. A.C.D.

324. Keeping Extraneous Matter Out of Cheese. J. W. Moore, Wis. Dept. of Agr. and Markets, State Capitol, Madison, Wis. Nat. Butter and Cheese J. *27*, 8, p. 12, April 25, 1936.

Twelve precautions are given to keep cheese free from extraneous matter. W.V.P.

325. Fermentations in Silage (A. I. V.) with Reference to Cheese Making. J. Van Beynum and J. W. Pette. Report for 1934 of the Experimental Dairy Farm, Hoorn, Holland, pp. 1–63, 1935 (English summary).

Butyric acid bacteria which were considered as a cause of gassy cheese and other abnormal fermentation were found in grass silage prepared by addition of mineral acids. The blowing of cheese was not always associated with large numbers of butyric acid bacteria.

It was found that the mineral acids were poorly mixed with the fodder and in the higher pH silage a lactic acid fermentation took place from the lactate-fermenting butyric acid bacteria, *Clostridium tyrobacterium*. This organism causes blowing in cheese. If the pH of the silage was 3.5, the sugar-fermenting butyric acid bacteria, *Clostridium saccharobutyricum*, predominates and it is not troublesome in cheese making.

It is suggested in making green forage silage that the pH should be

brought below 4 in all parts of the silage and that water be added to prevent respiration and activity of aerobic bacteria. A.C.D.

Another abstract of interest is number 319.

CHEMISTRY

326. On the Estimation of Phospholipids in Milk and Milk Products. B. J. HOLWERDA. Report for 1935 of the Experimental Dairy Farm, Hoorn, Holland, pp. 187–204, 1936 (English summary).

The contradictory data in the literature on phospholipids in milk and milk products was found to be due chiefly to a phosphoric ester in milk. It is extracted with fats and phospholipids, hence there is no direct quantitative method of determining phospholipids in milk. The organic phosphorus should be determined in the alcohol-ether extract of both milk and its skimmilk, the difference between the two values being phospholipid phosphorus.

Most published data are 3 to 5 times too high, the actual values should be .7 and .8 milligram per 100 millimeters. The phospholipids are associated with the fat in milk but this is not true for buttermilk. Fat free skimmilk is practically free from phospholipids.

A mono-amino phospholipid was isolated from milk, buttermilk, and the water phase of butter. A.C.D.

327. The Effect of Freezing on the Physical and Microscopic Character of Gels of Corn and Wheat Starches. SYBIL WOODRUFF AND HENRIETTA HAYDEN. J. Agr. Research *52*, 3, p. 233, Feb., 1936.

Starches prepared from three varieties of corn and one of wheat as nearly in their normal state as possible were used in making gels. Cornstarch made a well formed gel in 5 per cent aqueous solution by heating to 75° to 80° C. (167.0° F.) but wheat starch did not until heated to 95° C. (203° F.). The gels were frozen at −2° C. (28.4° F.) and also at the temperature of solid carbon dioxide. In gross appearance the frozen gels were very different from the original ones. The effect of freezing was greatest at −2° C. producing a sponge-like property in the gel. The frozen gel absorbed water and water solutions of iodine or dyes whereas the original gel did not.

Photomicrographs are shown of gelatinized, frozen corn and wheat starches. Veined areas appeared in gels after slow freezing whereas fewer changes occurred in the gels frozen at the temperature of solid carbon dioxide. L.M.T.

328. The Theroy of the Electrical Deacidification of Milk. JEAN PIEN AND JACQUES BAISSE. Lab. of the Farmers Union, Paris, France. Le Lait *16*, 159, p. 921, Nov., 1936.

A detailed study of the electrical deacidification of milk was made and it was concluded that lactic acid was not destroyed by the electrolysis. The electrolysis of a mixture of lactic acid and neutral salts resulted in no change in the acidity. In the presence of a protein, however, a deacidification resulted which may proceed as far as to render the solution alkaline. This phenomenon was a result of the blocking, by the protein, of the anion liberated by the electrolysis of salt. The cation neutralized the acidity of the solution. In the case of milk, the casein (and albumin) intervened in this sense and the anion fixed was particularly chloride originating from the electrolysis of chlorides. The sodium liberated at the cathode neutralized the lactic acid of the milk. The neutralized lactic acid was accounted for completely on analysis of the solution for lactates. The casein precipitated during the operation was found to contain considerable quantities of chloride. In the case of serum containing only a small content of protein, the electrolysis produced a certain amount of hypochlorite and neutralization was arrested due to lack of protein material. The electrical deacidification of a curdled milk was not possible because the precipitated casein did not react with the hypochlorite formed by electrolysis. There was a limit to the extent to which milk may be so deacidified by electrolysis (2.0 grams of lactic acid per liter of milk). This was determined largely by the chloride content of the milk. The experiments were conducted with platinum electrodes. When aluminum electrodes are used, milk may be deacidified to a greater extent because the aluminum originating from the electrode possesses neutralizing power for the lactic acid. The electrical deacidification was not considered a desirable method of treating milk as from the chemical, legal, or hygienic point of view it was equivalent to introducing into the milk soda or any alkaline product for reducing acidity. A.H.J.

329. Gelification of Casein in Relation with that of Milk. W. KOPACZEWSKI. Le Lait *16*, 158, p. 801, Sept.–Oct., 1936.

Dispersions of casein in caustic soda solutions are caused to gel by the addition of different chemical substances in a different manner from that described in the scattered literature on the subject. The gelifying action of different substances is additive, thus to the gelifying power of an acid such as lactic must be added the gelifying power of such a base as sodium hydroxide when the lactic acid is added to the caustic soda dispersion of the casein. Certain salts accelerate the gelification of dispersions of casein by a base, by an acid or by a totally different substance. The phenomenon of gelification by a substance sometimes assumes a character of periodicity as a function of the concentration employed. This is the case with hydrochloric acid. Some of the gels undergo a syneresis more or less rapidly. This is the case with gels obtained by the action of caustic soda on the dispersions of the casein in the more dilute caustic solution. In other cases syneresis does not

occur even at the end of 2 months. The gels containing soluble calcium liquefy on standing. The addition to the dispersion of casein in dilute sodium hydroxide of either lactic acid or calcium chloride results in the formation of a white membrane around each drop of the added solution. These membranes are dispersed by agitation of the solution. The action of electrolytes incapable by themselves of causing caustic solutions of casein to gel is confusing, some retard gelification, others accelerate it, and others do not appear to influence it one way or another in the experimental quantities used, others depend for their effect on the quantities used. The following ions accelerate gelification: chloride, bromide, sulfate, ferricyanide and phosphate for the anions and magnesium, cadmium, lanthanum, cerium for the cations. The following ions retard gelification: barium, copper, iron, aluminum, and tin. Lead, uranium, and thorium are without action and iodide, bicarbonate and carbonate may reverse their action depending on the quantity. The substances known as anticoagulants for blood such as oxalates, fluorides, and the arsenobenzenes appear to have no antigelifying effect on casein under the conditions of the experiment. A.H.J.

CONCENTRATED AND DRY MILK

Abstracts of interest are numbers 325, 326, 328, 329, 330, 336, 339, 360, 361, 363, 364, and 365.

FOOD VALUE

330. The Nutritive Value of Skimmilk Powders, with Special Reference to the Sensitivity of Milk Proteins to Heat. B. W. FAIRBANKS AND H. H. MITCHELL, Univ. of Illinois, Urbana. J. Agr. Research *51*, 12, p. 1107, 1935.

In this investigation the nutritive value of raw, liquid skimmilk was compared to that of four roller process powders and two spray process powders. All the skimmilk powders were obtained from one plant and from the same milk supply. The roller process powders used were: (1) Low temperature powder, produced at a steam gauge pressure of 50 pounds, (2) choice commercial powder produced at a steam gauge pressure of 87 pounds, (3) slightly scorched powder produced at a steam gauge pressure of 90 pounds with a thin film of milk on the drum, and (4) scorched powder produced at 90 pounds steam gauge pressure with the knives intermittently lifted from the rolls. One of the spray process powders was produced by the usual method, whereas the usual preheating was omitted from the process in manufacturing the other. The raw liquid skimmilk was obtained from the University of Illinois creamery.

Comparisons of the digestibility of energy, digestibility of protein, the net energy value and of the biological value of the proteins were carried out by feeding trials with white rats. The results show that the proteins of milk

are very sensitive to the intensities and durations of heat treatment employed in commercial drying. The digestibility of energy of the milk powders was reduced on the average 2.2 per cent as the result of drying. The digestibility of the proteins of skimmilk was reduced considerably by the roller process, especially when scorching occurred, and was slightly reduced in the spray process powder not preheated before drying but slightly increased in the spray powder when preheating before drying was employed. The various heat treatments did not affect the net energy value of the powders. As the temperature of drying in the roller process was increased until perceptible scorching occurred the biological value of the proteins was lowered rapidly. The first decline in biological value was attributed to destruction of cystine but further declines caused by more intense heat treatment were found to be the result of the destruction of lysine. L.M.T.

331. **Symposium on Vitamin D Ice Cream.** Health and Nutrition Authorities. Editorial. Ice Cream Trade J. *31*, 4, p. 19, April, 1935.

No attempt is made to summarize the information collected. Replies to six questions asked seemed to indicate (1) that it has never been proven that ice cream reinforced with vitamin D is the best method of feeding vitamin D to infants requiring it, (2) that foods and materials other than ice cream should be used in supplying this vitamin, (3) that it has never been proven that adults need more vitamin D than is received in the ordinary diet, (4) that it has never been proved that ice cream is an effective antirachitic agent, and if it were it is not fed early enough in life to be of much benefit to children who might need it, (5) opinion was about equally divided regarding the advisability of fortifying ice cream with vitamin D, and (6) opinion was about equally divided on the advisability of reinforcement of food products with vitamin D. W.H.M.

332. **Diabetic Ice Cream.** Editorial. Ice Cream Rev. *20*, 6, p. 50, 1936.

It is estimated that at present there are 400,000 people in the United States afflicted with diabetes. This should offer an attracive market for a "diabetic ice cream." An example of success along this line is cited. J.H.E.

ICE CREAM

333. **Merchandising Through Contests and Premiums.** Proc. 36th Ann. Conv. Intern. Assoc. Ice Cream Mfrs. *4*, p. 35, Oct., 1936.

A discussion led by Paul E. Reinhold, Foremost Dairies, Inc. Jacksonville, Fla.

Merchandising through premiums can be divided into three general classes. First, premiums to the consumer, second, premiums to the dealer, and third, premiums to the dispenser.

We have come to the conclusion that premiums to the consumer should be free goods of your own product. Premiums to the dealer were found to be of little help because the dealer does not come in contact with the ultimate consumer. However, premiums to the dispenser were found to be very profitable. By offering premiums to the dispensers, sales for the first month under this plan were more than double those of the same month of the preceding year.

(A) H. W. Brigham, Teall's Ice Cream Co., Rochester, N. Y.

This company offered 64 different premiums to boys and girls, each for a certain number of Eskimo Pie bags. The premium boards were prominently displayed in the dealer's store at the fountain. The main reason why this type of plan was adopted was because accumulating the bags stimulated a continuity of purchase.

Good premiums should be offered so as to stimulate interest. In our experience as many as 42 per cent of the bags were redeemed during some months, indicating great interest in the premiums. During the first year of the premium plan, the sale of Eskimo Pies per year increased from 450,000 to 3,000,000. Though premiums were not offered for the other items sold by the company, the sale of the other products advanced 15 to 25 per cent.

(B) L. A. Corning, Buttercup Ice Cream Co., Hamlet, N. C.

Our company has tried and is still using premiums; we believe free merchandise is the best type of premium. The sale of bulk ice cream increased 24.69 per cent and novelties 69.68 per cent, partly as a result of offering premiums. The increased business has affected favorably many cost figures, for example, delivery costs dropped 1 cent a gallon during the year.

(C) John H. Kloecker, Dixie Ice Cream Co., Lexington, Ky.

The author feels that premiums have a better possibility of producing sales than contests. He advocates that premiums be given often and immediately at the point of sale in one of the forms of the forms of the ice cream being sold rather than with other goods.

(D) Carl A. Steele, Steel-DeSoto Ice Cream Co., Minneapolis, Minn.

Merchandising through contests and premiums may produce a stimulating effect on sales which is only temporary. Furthermore, competitors with more liberal premiums may win away business which is won through premiums.

Eventually legislation outlawing this type of advertising may be passed. Eventually, the industry must make a fair analysis of costs, and once again put its products on the market with a fair margin of profit and a reasonable price to the consumer. M.J.M.

334. Maintaining Refrigeration Equipment at the Peak Efficiency Level. JAMES M. KOVINO. Ice Cream Trade J. *30*, 6, p. 19, June, 1935.

The upkeep and maintenance of a refrigeration system divides itself into two phases: first, upkeep of mechanical and electrical machinery; and second, upkeep of the refrigerant itself.

The compressor is probably the most important mechanical piece of equipment and the best method of checking its efficiency is by means of an indicator. The oil used in the compressor is of prime importance in the efficiency of the equipment. Particular care should be given the oiling system of the stuffing box, and it should be watched carefully as it is a common source of trouble. The piston rod and cylinder walls also require attention if the compressor is to operate efficiently.

The principal thing to watch about the condenser is cleanliness. The tubes must be free from scale to permit rapid heat transfer. Foreign gases must be removed from a system if it is to operate efficiently. These may be removed through purging valves or on newer machines by a noncondensible gas separator.

Tools suitable for the machinery used should be kept on hand. Flow meters should be installed to check the amount of brine, water and ammonia pumped. The brine should be checked occasionally and kept strong enough to prevent freezing. The purity of the liquid ammonia should be checked occasionally by drawing a portion into a graduated cylinder and noting the amount that does not evaporate. W.H.M.

335. Compressing Hardened Ice Cream to Produce Uniform Density. O. E. WILLIAMS, Research Lab., U. S. Bureau of Dairy Industry. Ice Cream Trade J. *31*, 4, p. 31, April, 1935.

Most ice cream makers have at one time or another experienced difficulty in maintaining a standard or uniform density of their product. The author has devised a method of increasing the density of hardened ice cream by means of pressure. The process is designed to remove only the desired amount of air from the ice cream without melting it or increasing the size of the original crystal formation.

The value of such a process lies in the standardization of the product to a given density and the ease with which low density ice cream can be produced. The latter is especially true of some batch freezers where it is difficult to hold down the overrun.

The author has used three types of presses and found the hydraulic press to be most satisfactory. Ice cream with densities between 4.5 and 5 pounds per gallon at temperatures of 0 to 8° F. were easily compressed to 66 per cent of their original volume in both large and small cans. W.H.M.

336. Ice Cream with High Solids. A. C. DAHLBERG, N. Y. Agr. Exp. Sta., Geneva, N. Y. Ice Cream Trade J. *31*, 1, p. 30, Jan., 1935.

Recent years have seen a tendency toward the manufacture of high solids ice cream. There are two properties of milk solids-not-fat which have limited their use in building up solids in ice cream. They are: first, development of sandiness as a result of crystals, and second, the tendency for the production of a characteristic cooked or heated flavor. Methods are being

advanced to overcome these objections which consist chiefly of improved milk solids-not-fat with reduced lactose content or improved methods of incorporation in the mix. W.H.M.

337. What's Wrong with Packaged Goods When It Reaches the Consumer? A. C. SCHRICKER, St. Louis Dairy Co., Missouri. Ice Cream Trade J. *31*, 1, p. 27, Jan., 1935.

In an effort to determine what is wrong with packaged goods when it reaches the consumer, the Research Committee of the Missouri Association of Ice Cream Manufacturers made a careful survey of the condition and flavor of packaged ice cream picked up at various points of sale.

The types of packages were studied in this survey. One was the Neapolitan or the three layer brick of vanilla, strawberry and chocolate. The other was a special flavor or combination of flavors which were put on the market irregularly.

The samples were scored as good, fair, and poor in regard to flavor; good, slightly coarse, and coarse in regard to texture; and as good or soiled in regard to package appearance. A summary of flavor rating of the Neapolitan packages with the percentages that scored as good are as follows: vanilla, 77.1 per cent; chocolate, 77.1 per cent, strawberry, 71.4 per cent. Percentages scoring as fair: vanilla, 14.3 per cent; chocolate, 11.45 per cent; strawberry, 17.4 per cent. Percentages scoring as poor: vanilla, 8.6 per cent; chocolate, 11.45 per cent; strawberry, 11.4 per cent. From this it is evident that the keeping quality of the package of ice cream is no better than that of the strawberry ice cream in it.

The special packages were scored as follows: good 81.5 per cent, fair 14.8 per cent, poor 3.7 per cent. The higher per cent of good flavors in this class of package is probably due to the fact that samples picked up were specials and the manufacturer is sure of a positive turnover before putting out another.

The percentages of the flavors ranking as coarse indicated that again the strawberry ice cream is the weak link. The special packages again show up better than the Neapolitan and probably because of the more rapid turnover. W.H.M.

338. The Use of Sugars in Making Good Quality Ice Cream. P. S. LUCA, Michigan State College, East Lansing, Michigan. Ice Cream Trade J. *32*, 4, p. 34, April, 1936.

A discussion is presented on the importance of sugar as a source of solids in ice cream mix. Tables of data are given on the effect of sugar on the specific gravity of the mix, the freezing-point of the mix, the time required to reach maximum overrun, the per cent maximum overrun, and a table of scores for body and texture of ice cream containing various concentrations of sugar.

It was concluded that 15 per cent sugar so improved palatability and body as compared with lower percentages and is such a cheap source of solids that the advantages outweighed the disadvantages. It was further concluded that other sources of sweetening than sucrose are uneconomical unless used for purposes other than sweetening. W.H.M.

339. The Kniaseff Method for Finding the Fat Content of Ice Cream. D. H. NELSON, Dairy Industry Div., Univ. of Calif., Davis, Calif. Ice Cream Trade J. *22*, 11, p. 19, Nov., 1936.

A study was made to test the accuracy of the Kniaseff method of testing. Various lots of mixes and frozen ice creams were tested by unskilled technicians and the results compared with those obtained by the Mojonnier method. When a 9 gram 50 per cent cream test bottle was used, 97.1 per cent of the unfrozen mix samples and 72.4 per cent of the frozen samples deviated .5 per cent or less from the Mojonnier test. When 18 gram 8 per cent whole milk test bottles were used, 84.4 per cent of the samples tested deviated from .3 to .5 per cent from the Mojonnier and 15.6 per cent deviated .2 per cent or less. Satisfactory results were also obtained on chocolate, strawberry and banana ice cream, ice milk and fresh chocolate milk drink. The method was not satisfactory for buttermilk. Accuracy and duplicability of the test suffered when 18 gram 50 per cent cream test bottles were used. Detailed directions for making the test are given. W.H.M.

340. When Consumers Talk Back. H. P. LONGSTAFF, Univ. of Minn., St. Paul, Minn. Ice Cream Trade J. *31*, 1, p. 13, Jan., 1935.

This article deals with the results of an ice cream consumer survey to determine their likes and dislikes. One hundred and forty-five consumers were interviewed by students in advanced advertising research at the University of Minnesota. Questions asked dealt with frequency of serving, preference for a home-made product, preference for dipped ice cream over factory filled packages, place of purchase, quantities purchased, and knowledge of food value. The answers to these and many other questions would be of value to ice cream manufacturers in analyzing the desires of their customers regarding ice cream. W.H.M.

341. Manufacture of Vanilla Ice Cream. C. C. TOTMAN, South Dakota State College, Brookings, South Dakota. Ice Cream Trade J. *31*, 2, p. 23, Feb., 1935.

The author discusses procurement, quality and storage of dairy products for ice cream, sources and amount of vanilla flavor, aging, freezing, and hardening of ice cream. A diagrammatic scheme showing the percentage of fat and total solids to use in a mix is presented. W.H.M.

342. Manufacture of Chocolate Ice Cream. W. H. MARTIN, Kansas State College, Manhattan, Kansas. Ice Cream Trade J. *31*, 3, p. 19, March, 1935.

Recommendations are given on the amount of chocolate flavoring material to be used in mixes of varying composition. Four formulae are also given for chocolate mixes together with directions on processing and freezing. Caues and remedies for various chocolate ice cream defects are discussed.

W.H.M.

343. Manufacture of Strawberry Ice Cream. P. H. TRACY, Univ. of Illinois, Urbana, Ill. Ice Cream Trade J. *31*, 4, p. 15, April, 1935.

Four phases of the problem discussed are: proper selection of fruit and flavoring material, proper sanitary control, correct processing and correct merchandising.

The article includes a description of the methods used in the preparation of strawberry flavor, methods used in packing strawberries for use in ice cream, and the causes and remedies for the stale, metallic flavor which frequently occurs in strawberry ice cream. Protection against copper contamination from equipment and rapid turnover in the plant and store are suggested as essential in the making and selling of a good product.

W.H.M.

344. Manufacture of Fruit Ice Cream. W. C. COLE, Dairy Industry Div., Univ. of Calif., Davis, Calif. Ice Cream Trade J. *31*, 5, p. 17, May, 1935.

Five simple rules are given for the making of good fruit ice cream. They are: carefully select fruit, prepare it properly before adding to other ingredients, use enough fruit to justify the name, be sure that the fruit imparts the characteristic flavor desired, and lastly freeze the ice cream in such a way as to produce a smooth textured product and then serve it while fresh. W.H.M.

345. Malted Milks Make Money. N. S. MACINTOSH. Ice Cream Trade J. *31*, 7, p. 13, July, 1935.

Directions are given for the making of several fountain malted milk drinks including frozen malted milk. Formulae and cost figures are also given for various items served at the soda fountain. W.H.M.

346. A Book Review Delayed 105 Years. Editorial. Ice Cream Trade J. *31*, 7, p. 15, July, 1935.

This article is a review of a book, "The Art of Ice Cream Making" by Friedrich Goetz written in 1830. The review is continued in the August, 1935, issue of the Ice Cream Trade Journal giving a description of the art of making fancy forms. W.H.M.

347. Here Is How to Use Stabilizers in Making Ices and Sherbets. P. H. TRACY, Univ. of Ill., Urbana, Ill. Ice Cream Trade J. *31*, 7, p. 21, July, 1935.

The correct amount of gelatin to use can be determined in the following manner:

1. Acidify water with citric acid so that it will correspond with the acidity of the ice or sherbet to be made.
2. Dissolve 10 grams of the gelatin in 990 c.c. of the acidified water.
3. Heat the gelatin solution to 145° F. for 10 minutes and then cool to about 60° F.
4. From the one per cent stock solution prepare solutions varying from 0.4 to 0.8 per cent. (using the acidified water) with .05 per cent intervals. One hundred cubic centimeter graduates can be used for making up these solutions.
5. Pour about 10 c.c. of the standardized solution into each of two tubes.
6. Place the tubes in a 40° F. bath for 18–24 hours.
7. Invert the tubes and select the one that will just stand inverted without leaking for about 30 seconds.
8. Multiply the percentage of gelatin in the selected tube by the percentage of liquid in the gelatin or sherbet and divide by 100. The result is the amount of gelatin needed.

Example:

(a) Gelatin concentration in tube selected, 0.6 per cent

(b) Percentage of liquid in sherbet = 100 − [30 (per cent sugar)] + [15 × .4 (per cent solids in mix used)] = 74

(c) $\frac{.6 \times 74}{100} = .444 =$ percentage of gelatin needed.

Vegetable gums and pectin are also discussed and directions given for their use. The discussion is continued (Ibid. 31, 7, p. 31) in which sherbet defects are discussed and suggested formulae given. W.H.M.

348. The A B C of Making the Mix. H. A. ACKERMAN, Hydrox Corp., Chicago, Ill. Ice Cream Trade J. *31*, 7, p. 27, July, 1935.

The author describes the various phases of mix making, calling attention to the importance of technical control, sources, ingredients for fat and serum solids, amounts of serum solids, stabilizer and eggs to use, manner of processing, homogenization pressures, pasteurization temperatures and aging periods. W.H.M.

349. The Dairy Scientists' Find. J. C. HENING, N. Y. State Agr. Exp. Sta., Geneva, N. Y. Ice Cream Trade J. *31*, 8, p. 29, Aug., 1935.

This article contains a brief summary of the results of recent scientific investigation in the field of ice cream making which were reported at the 13th annual meeting of the Dairy Science Association at the University of Minnesota, June 24–27, 1935. W.H.M.

350. The Year's Research Record. A. C. DAHLBERG, N. Y. Agr. Exp. Sta., Geneva, N. Y. Ice Cream Trade J. *31,* 10, p. 19, Oct., 1935.

The article reviews briefly some of the research work in the field of ice cream making, conducted by government, college and plant laboratories during the past year. W.H.M.

351. Steel or Single Service Cans. By Milk and Ice Cream Institute, Cleveland, Ohio. Ice Cream Trade J. *32,* 4, p. 32, April, 1936.

The results of a survey of 1303 dealers indicated that 62.3 per cent prefer to handle ice cream in steel cans, 22.5 per cent prefer single service containers. Figures are presented estimating the cost of using steel cans to be .0455, .0567, .0374, and .0303 cents per trip for plants of 100,000; 250,000; 500,000 and 1,000,000 gallons annual capacity respectively. Single service containers make it possible to take care of dealers during the month of high production with a minimum investiment in steel cans. W.H.M.

352. The Dairy Scientists' Find. A. C. DAHLBERG, N. Y. State Agr. Exp. Sta., Geneva, N. Y. Ice Cream Trade J. *32,* 7, p. 23, July, 1936.

This article presents short reviews of the various papers pertaining to ice cream making which were presented at the 31st annual meeting of the American Dairy Science Association. W.H.M.

353. Ice Cream Sales Index for 1936. Special Bulletin No. 56, Intern. Assoc. Ice Cream Mfrs., 1105 Barr Bldg., Washington, D. C. April, 1937.

The bulletin contains an analysis of ice cream sales in 1936 compared with 1935 for the United States and Canada. Each month in 1936 showed greater sales than in 1935, the average increase for the year for the United States being 22.26 per cent. For Canada the year 1936 showed an increase in total sales of 13.88 per cent over 1935. Business and weather conditions were both favorable for the ice cream industry during the year.

The data are also tabulated so as to show the sales index by states. A condensed climatological summary of temperatures for each state is included as well as a summary of general business conditions for the year.

A supplement is contained in the bulletin which shows in graphic form ice cream and industrial production from 1929 to 1936, inclusive. Ice cream sales in 1936 were nearer to the 1929 level than for any other year and were considerably above the 10-year average (1923–1932).

M.J.M.

354. Fighting Moisture in Ice Cream Bodies. HARVEY LINDSAY, Pres., Dry-Zero Corp., Chicago, Ill. Ice Cream Rev. *20,* 8, 1937.

Insulating material which takes up moisture is of little value. In pre-

venting moisture absorption in truck bodies the first step is to provide a moisture seal between the insulation and outer air. Duplex waterproof kraft paper with edges sealed in hot asphalt is satisfactory for this purpose. The second step is to use insulating material that does not absorb moisture. The need for a properly vented inside liner in the truck body is discussed.

J.H.E.

355. Development of Oxidized Fat Flavors in Stored Frozen Cream and Ice Cream. H. H. SOMMER, Univ. of Wis., Madison, Wis. Ice Cream Rev. *20*, 7, p. 62, Feb., 1937.

The author comments upon and abstracts some of the recent work of Thurston and coworkers in which the view is advanced that lecithin in milk is probably the mother substance of the oxidized flavor rather than the milk fat. The author suggests the reader exercise caution and not to adopt this conclusion too irrevocably in the present development of the subject.

J.H.E.

356. Physical and Bacteriological Tests on Commercial Ice Cream Samples. H. H. SOMMER, Univ. of Wis., Madison, Wis. Ice Cream Rev. *20*, 6, p. 38, Jan., 1937.

At the annual convention of the Wisconsin Association of Ice Cream Manufacturers 21 manufacturers submitted samples of chocolate and vanilla ice cream for scoring and other observations. The bacterial counts are reported. They were generally low with only one sample exceeding a count of 100,000 colonies per gram. The pH of the vanilla samples ranged from 6.34 to 6.91. In the case of the chocolate ice cream the range was from 6.26 to 7.43.

Colors of the hardened ice cream samples were matched against the standard Lovibond tintometer slides. Considerable variation in color was noted among the samples.

The resistance of the ice cream to penetration was measured by means of the New York testing laboratory standard type penetrometer. There was quite a difference in resistance of the samples to penetration, but little correlation was obtained between penetration measurements and the melting behavior of the ice cream.

In the melting behavior of the samples there was exhibited extremely wide differences. The melt down ranged from a desirable creamy, non-foamy liquid, to samples which remained on the screen as a jelly-like foamy mass.

J.H.E.

Other abstracts of interest are numbers 320, 326, 327, 328, 329, 330, 331, 332, 357, 359, 360, 362, 363, and 364.

MILK

357. Whipping Cream for Decorations and for Various Specialties. J. P. SMITH. Ice Cream Trade J. *31*, 2, p. 35, 1935.

For hand whipping select fresh sweet cream, testing 25 to 30 per cent butterfat, age 24 hours at 36° F. or lower, but avoid freezing, and add powdered sugar, flavor and color after cream is whipped. Gelatine, if used, should be dissolved (2 ounces in 1 pint of water), add one to one and one-half pounds of sugar to hot gelatine solution, chill until syrupy, then whip until fluffy and then combine it with 3 quarts of cream that have been previously whipped.

For mechanical whipping 20 to 25 per cent fat cream is preferable. Formula and directions are given for making commercially whipped cream and charlotte russe topping.

17 quarts 40 per cent fat cream
17 " whole milk
8 pounds granulated sugar
9 ounces gelatine

Dissolve gelatine in 1½ quarts water and add sugar. Whip milk and cream at high speed until near "breaking" point, then whip at low speed, add hot gelatine and sugar slowly, and continue whipping just long enough to mix thoroughly. W.H.M.

358. The Influence of the Age of Milk on the Sensibility to the Starch Reaction. JAROSLAV MASEK, The Inst. of Lactology of the Polytech. School, Prague, Tschecoslovacia. Le Lait *16*, 159, p. 941, Nov., 1936.

Milk that had been flash pasteurized at 88° C. (190.4° F.) gave a negative Storch reaction immediately after pasteurization while when held at room temperature, 17° C. (62.6° F.) for 24 hours, the same milk showed a tendency to give a positive Storch reaction. Some milk pasteurized in the same way but to which raw milk had been added in the ratio of 10 parts of pasteurized to 3 parts of raw milk initially gave a positive Storch reaction but after holding for 24 hours the reaction became negative. The addition of lactic acid to the milks so that the final acidity became 35° D (approximately .35% lactic acid) did not change their reaction to the Storch test. A.H.J.

359. The Formation of Foam in Cream, Milk and Skimmilk. H. A. SIRKS. Report for 1935 of the Experimental Dairy Farm, Hoorn, Holland, pp. 1–60, 1936 (English summary).

In comparing maximum foam formation between 12° and 18° C. (53.6 and 64.4° F.) produced by churning sweet and sour skimmilk, it was found that more foam formed at the lower temperature. The reverse was true

when finely divided air was passed through the sour skimmilk. Similar results were secured by churning sweet or sour milk or cream. Blowing air through ripened cream gave greatest volumes at the lower temperature, the same as churning.

Maximum foam was secured by churning skimmilk at an acidity near the curdling point but the total volume was less than for sweet skimmilk. The churning time was influenced very slightly by acidification.

The maximum foaming produced by churning was rather uniform for sweet, ripened, raw, and pasteurized creams. In churning pasteurized cream the lessening of the volume was greater and the churning time shorter than for raw cream.

The addition of butter oil to skimmilk reduced the foam produced by churning, especially at higher temperatures and in acidified skimmilk.

Microscopic examination of the foam of ripened cream showed that a higher churning temperature which produced faster churning also produced smaller air cells. However, the total air surface was not increased as the volume was correspondingly less. A.C.D.

360. Measurements of the Distribution of the Different Sized Fat Globules in Milk and Buttermilk. H. A. SIRKS. Report for 1934 of the Experimental Dairy Farm, Hoorn, Holland, pp. 163–190, 1935 (English summary).

The number and the size of the fat globules in milk and buttermilk was accurately counted and measured. The problem is complicated for buttermilk as some fat globules were 80 microns in diameter. From the number and size of the fat globules and the specific gravity of the fat, the weight of the fat and its percentage in the milk and buttermilk was calculated.

It was found that results of microscopic examination and calculation agreed with the Gerber test of the milk but was far below the Gerber results for buttermilk. The author concludes that fat exists in buttermilk which is invisible microscopically. A.C.D.

361. More About How the Milk Market Was Stabilized in Port Arthur, Texas. J. C. WATKINS, Port Arthur Chamber of Commerce, Port Arthur, Texas. Milk Dealer *26*, 6, p. 46, March, 1937.

Additional information about stabilizing the milk market in Port Arthur, Texas, is given. The author summarizes the strong links in a cooperative organization as follows:

1. Voluntary association.
contract in any way.
2. Ability of the association itself to punish members who violate their
3. The power to obtain injunctions against further violations.
4. The unfaltering enforcement of the terms of the contract without a moment's delay, as soon as it is determined that a member has failed to keep his agreement in any particular. C.J.B.

362. The Effect of Homogenization on Some of the Characteristics of Milk Fat. I. A. GOULD AND G. M. TROUT, Michigan State College. J. Agr. Research *52*, 1, p. 49, Jan., 1936.

Five trials were made with butter fats obtained in each trial by churning separated cream from each of four lots of milk handled as follows: Lot 1, pasteurized at 145° F. for 30 minutes; lot 2, pasteurized at 145° F. for 30 minutes and then homogenized at 1500 pounds pressure; lot 3, warmed to 100° F., homogenized at 1500 pounds pressure and immediately thereafter pasteurized; lot 4, homogenized at 100° F., cooled to 55° over a surface cooler, stored at 35 to 40° F. for 24 hours and then pasteurized.

No appreciable differences in the Reichert-Meissl number, Polensky number, refractive index or acid degree occurred in the fat when the pasteurized milk was homogenized. However, when raw milk was homogenized, the acid degree of the fat increased four- to sixfold within a few minutes and about twentyfold after 24 hours storage. Homogenization of the raw milks did not cause any appreciable change in the Reichart-Meissl number, Polenski number or refractive index of the fat.

The authors conclude that the measurement of free fatty acids by titration of the fat appears to be a more accurate and more sensitive means of determining the rate of fat-splitting action than those determinations which may be made on the milk.

The results also included a verification of previous findings that the titratable acidity and hydrogen ion concentration of raw milk are increased in raw milk following homogenization. L.M.T.

Other abstracts of interest are numbers 320, 325, 326, 328, 329, 330, 331, 339, 355, 356, 363, and 364.

MISCELLANEOUS

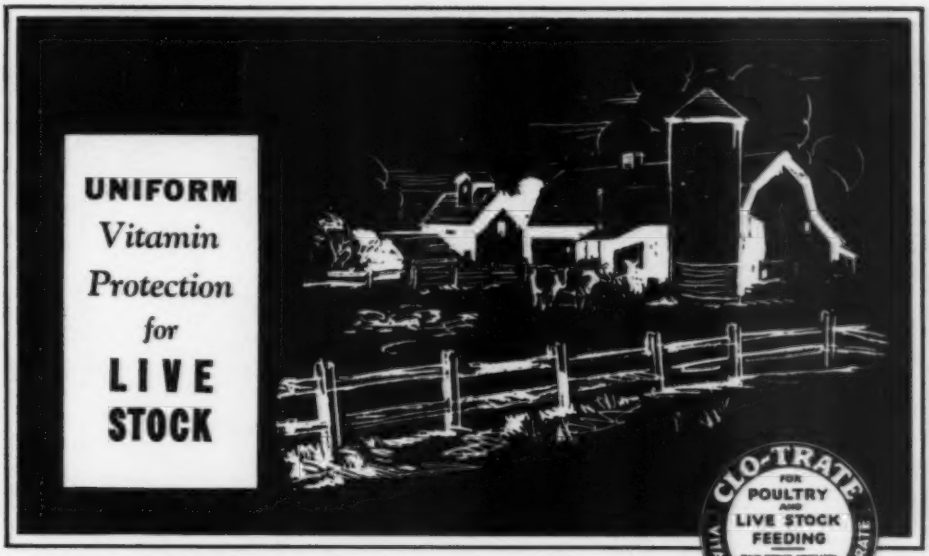
363. Getting the Most Out of Steam. F. J. VONACHEN, Troy Engine and Machine Co., Troy, Pa. Ice Cream Rev. *20*, 5, p. 26, 1936.

Steam can be made to do double duty by passing it through a prime mover and using the exhaust for heating and processing in place of live steam. Specifications for modern steam engines are discussed.

J.H.E.

364. Reducing the Number of Accidents in Milk Plants. Milk Dealer *26*, 6, p. 112, March, 1937.

Safe practices to prevent accidents at the various danger points in a milk plant are given. C.J.B.



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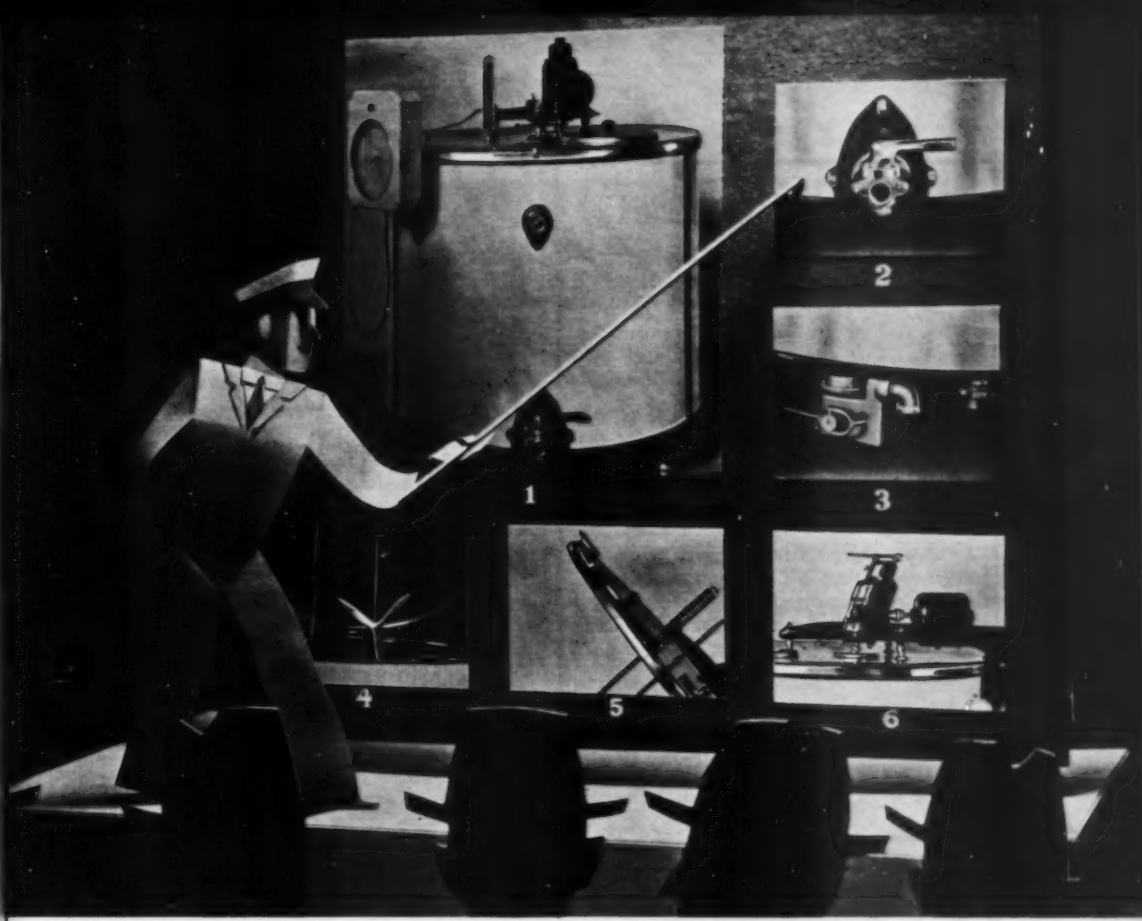

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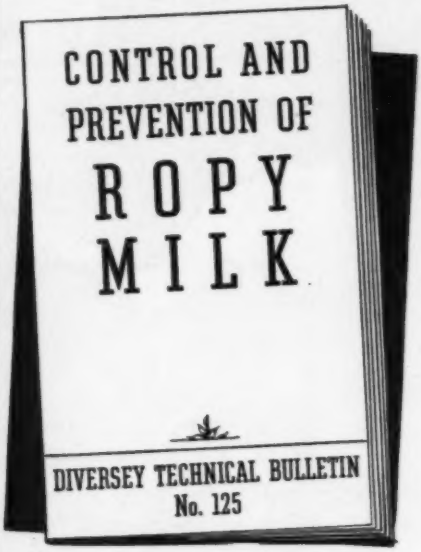

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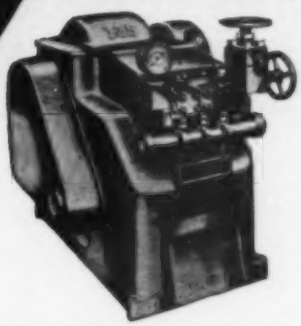

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